5.0 ENVIRONMENTAL CONSEQUENCES

This section involves both a qualitative and quantitative comparative assessment of the alternatives, as discussed in Section 3.0, and their potential effect on known resources. The following section includes the anticipated changes to the existing environment including direct, indirect, and cumulative effects within the Permit Area (see Section 4.1 for Permit Area description). A summary of the impacts and changes expected to result from the implementation of each alternative is presented at the end of this section (Table 21).

As discussed in Section 1, the Town of North Topsail Beach is seeking Federal and State permits to allow implementation of a non-Federal shoreline and inlet management project that would preserve the Town's tax base, protect its infrastructure, and maintain its tourist oriented economy (see Section 1.6 for details). The goals, needs and objectives of the North Topsail Beach Shoreline Protection Project are summarized as follows:

- Long-term stabilization of the oceanfront shoreline located immediately south of New River Inlet;
- Provide short-term protection to the 31 imminently threatened residential structures over the next zero to five years;
- Provide long-term protection to Town infrastructure and approximately 1,200 homes;
- Reduce or mitigate for historic shoreline erosion along 11.1 miles of oceanfront shoreline of North Topsail Beach;
- Improve recreational opportunities along the Town's oceanfront shoreline;
- Acquire beach compatible material for shore protection project;
- Maintain the Town's tax base by protecting existing development and infrastructure on the oceanfront shoreline of North Topsail Beach; and
- Balance the needs of the human environment by minimizing and avoiding negative effects to natural resources.

Table 21, shown below, provides a summary of the impacts expected to result from the implementation of each alternative. Physical direct (1 to 2 years), indirect (5 to 10 years) and cumulative (more than 30 years) effects of alternatives on habitats were calculated as acreage amounts and are based on the following:

- August 2005 surveyed and estimated mean high water line, February 2005 aerial photography, biotic community mapping through aerial interpretation and the GIS developed for the project.

- For Alternatives 1 and 2, shoreline change rates along North Topsail Beach (NTB) were determined using historical shoreline positions from 1983 to 2002 with a 3.6 ft/yr erosion rate along the northern section, 3.4 ft/yr erosion rate along the central section and 1.2 ft/yr erosion rate along the southern section. Shoreline change rates along the southern end of Onslow Beach were determined using historical shoreline positions from 1962 to 1984 (see Appendix B – Engineering Analysis) with an 18.2 ft/yr erosion rate.

- For Alternatives 3, 4, 5, and 6, shoreline change rates along North Topsail Beach were not calculated due to the area at the extreme northeast end of North Topsail Beach between baseline stations 1135+00 to 1165+00, which is predicted to accrete following the relocation of the ocean bar channel of New River Inlet (negating existing shoreline erosion); as well as the addition of beach fill along 11.1 miles of oceanfront shoreline on North Topsail Beach. Shoreline change rates for Onslow Beach were determined using historical shoreline positions from 1962 to 1984 (see Appendix B – Engineering Analysis) with a 7.9 ft/yr erosion rate for Alternatives 3 and 6 (involve channel relocation) and 18.2 ft/yr erosion rate for Alternatives 4 and 5 (without channel relocation or one-time channel relocation).

- Numerical modeling was performed to assess the amount of habitat, expressed in acres, which were impacted along North Topsail Beach and Onslow Beach for each alternative. As shown in Table 21, high marsh, residential and upland hammock would have a small erosive or negative impact (less than 7 acres cumulatively) from any of the alternatives. Alternatives 3 through 6 will affect only the southern end of Onslow Beach since beach nourishment activities are not planned for this area. Although modeling results did not indicate empirical impacts (in terms of acreages) to a number of habitat types, the environmental consequences for these habitats are discussed in detail in Section 5.3 below.

Table 21
Physical Effects of Alternatives on Habitats (Net Loss in Acres)

Natural Resource	Total Approx. Acres in Permit Area	Impact Type	Alt. #1 No action		Alt. #2 Buy Out/ Relocation		Alt. # 3 Inlet Management Plan with Beach Nourishment		Alt. # 4 Beach Nourishment without Channel Relocation		Alt. #5 Beach Nourishment with One-Time Channel Relocation		Alt. # 6 Inlet Management Plan	
			NTB	OB	NTB	OB	NTB	OB	NTB	OB	NTB	OB	NTB	OB
High Marsh	8	Direct	0	0	0	0	0	0	0	0	0	0	0	0
		Indirect	0	0	0	0	0	0	0	0	0	0	0	0
		Cumul.	0	4	0	4	0	0	0	4	0	4	0	0
		Total	**0**	**4**	**0**	**4**	**0**	**0**	**0**	**4**	**0**	**4**	**0**	**0**
Upland Hammock	55	Direct	0	0	0	0	0	0	0	0	0	0	0	0
		Indirect	0	0	0	0	0	0	0	0	0	0	0	0
		Cumul.	0	3	0	3	0	0	0	3	0	3	0	0
		Total	**0**	**3**	**0**	**3**	**0**	**0**	**0**	**3**	**0**	**3**	**0**	**0**
Marine Intertidal	488	Direct	6	5	7	5	0	3	0	5	0	5	0	3
		Indirect	27	1	27	1	0	3	0	1	0	1	0	3
		Cumul.	35	0	35	0	0	0	0	0	0	0	0	0
		Total	**68**	**6**	**68**	**6**	**0**	**6**	**0**	**6**	**0**	**6**	**0**	**6**
Dune	111	Direct	0	1	0	1	0	1	0	1	0	1	0	1
		Indirect	0	4	0	4	0	6	0	4	0	4	0	6
		Cumul.	1	31	1	31	0	7	0	31	0	31	0	7
		Total	**1**	**35**	**1**	**35**	**0**	**14**	**0**	**35**	**0**	**35**	**0**	**14**
Dry Beach	125	Direct	0	3	0	3	0	1	0	3	0	3	0	1
		Indirect	3	15	3	15	0	8	0	15	0	15	0	8
		Cumul.	30	11	31	11	0	14	0	11	0	11	0	14
		Total	**33**	**29**	**33**	**29**	**0**	**22**	**0**	**29**	**0**	**29**	**0**	**22**

Natural Resource	Total Approx. Acres in Permit Area	Impact Type	Alt. #1 No action		Alt. #2 Buy Out/ Relocation		Alt. # 3 Inlet Management Plan with Beach Nourishment		Alt. # 4 Beach Nourishment without Channel Relocation		Alt. #5 Beach Nourishment with One-Time Channel Relocation		Alt. # 6 Inlet Management Plan	
			NTB	OB	NTB	OB	NTB	OB	NTB	OB	NTB	OB	NTB	OB
Low Marsh	64	Direct	0	0	0	0	0	0	0	0	0	0	0	0
		Indirect	0	0	0	0	0	0	0	0	0	0	0	0
		Cumul.	0	0	0	0	0	0	0	0	0	0	0	0
		Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Estuarine	38	Direct	0	0	0	0	0	0	0	0	0	0	0	0
		Indirect	0	0	0	0	0	0	0	0	0	0	0	0
		Cumul.	0	0	0	0	0	0	0	0	0	0	0	0
		Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Intertidal Shoal	130	Direct	0	0	0	0	0	0	0	0	0	0	0	0
		Indirect	0	0	0	0	0	0	0	0	0	0	0	0
		Cumul.	0	0	0	0	0	0	0	0	0	0	0	0
		Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Subtidal	1,879	Direct	0	0	0	0	0	0	0	0	0	0	0	0
		Indirect	0	0	0	0	0	0	0	0	0	0	0	0
		Cumul.	0	0	0	0	0	0	0	0	0	0	0	0
		Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

1) Notes: NTB = North Topsail Beach; OB = Onslow Beach
2) Acreage impacts for the northern, central and southern sections were combined to create one impact acreage.

5.1 ALTERNATIVES ELIMINATED FROM FURTHER CONSIDERATION

Early consideration of channel modifications for New River Inlet included possible deepening and widening of Cedar Bush Cut, the channel connecting New River Inlet with the AIWW. However, the connecting channel was removed from the design in the early stages of project coordination and development due to the direct impacts to softbottom communities and potential indirect impacts to salt marsh, shellfish habitat and unknown submerged aquatic vegetative communities in the Inlet complex.

A group of citizens who own property along the north end of North Topsail Beach proposed using Holmberg Technologies, as an alternative to beach nourishment and channel relocation, as a means to protect the entire North Topsail Beach shoreline. Holmberg Technologies is a proprietary shoreline protection device that consists of a series of low lying concrete filled nylon bags constructed perpendicular to the shoreline. In October 1998, the North Carolina Coastal Hazards Science Panel, a panel of coastal experts established by the CRC to provide technical advice to the CRC on complicated matters, reported to the CRC that the Holmberg Technologies was not an innovative erosion control device in that it had all the characteristics of a groin system. Since the Coastal Hazards Science Panel report preceded the 2003 modification to the CAMA, CRC rules in effect at the time would prohibit the use of the Holmberg Technologies in North Carolina. With the 2003 modification of CAMA referenced above, Holmberg Technologies are prohibited by State Law along with all other types of hard erosion control measures.

The use of hard structures as a shoreline erosion response measure for ocean and inlet shorelines is prohibited by the State of North Carolina. Prior to 2003, the hard structure prohibition was controlled by regulations enacted by the N.C. Coastal Resources Commission (CRC) in response to the Coastal Area Management Act. In 2003, the N.C. State Legislature passed a law (Session Law 2003-427, § 113A-115.1) specifically prohibiting the construction of breakwaters, bulkheads, groins, jetties, revetments, seawalls, and similar structures in response to ocean and inlet shoreline erosion. CAMA notwithstanding, a terminal groin alternative, Alternative 7, was evaluated as a possible means of protecting development on North Topsail Beach located adjacent to the south shoulder of New River Inlet. Due to current legislation this alternative has been eliminated from further consideration and evaluation.

It should be noted that, during the 2007 North Carolina Legislative Session, the House passed a bill that would allow the installation of an experimental terminal groin at an unspecified inlet. The bill would require the groin to be evaluated in an Environmental Impact Statement and approved by the CRC prior to installation. The bill moved to the NC Senate (Senate Bill 599) but no action was taken prior to adjournment of the Session. Most recently, HB709 was introduced and requires the North Carolina Coastal Resources Commission to conduct a

study of the feasibility and advisability of the use of terminal groins as erosion control devices. The results of this study will be submitted to the Environmental Review Commission and the General Assembly by April 1, 2010.

5.2 GENERAL ENVIRONMENTAL CONSEQUENCES (FOR PERMIT AREA)

The alternative actions carried forth and considered for implementation have environmental consequences associated with them and are discussed in greater detail in the following sections. Although the scope of the habitat and resource mapping conducted by the Town of North Topsail Beach encompasses a much larger investigation area, only those resources within the USACE defined Permit Area (Figures 8a through 8c) are discussed and evaluated in detail.

The narrative (Section 5.3) and Table 21 provided above is an acreage estimate of effects expected to result from the implementation of each alternative on the specific marine, estuarine, and upland habitat within the Permit Area. This general overview of effects based on habitats is provided to allow the reviewer the opportunity to evaluate the specific alternatives and their effect on the biological communities within the Permit Area. Further evaluation of the direct, indirect, and cumulative effects of each alternative on specific natural resources is presented in recognition that many of the resources are found within, or utilize numerous habitats through their life cycle. Also refer to Appendix F– Cumulative Effects Assessment.

Four (4) alternatives (Alternatives 3, 4, 5, and 6) involve various combinations of beach fill and/or inlet management options that would provide varying degrees of protection. Each of these alternatives incorporates the dredging of material from either the New River Inlet, offshore borrow areas, or a combination of both. They also all involved the placement of fill material along stretches of North Topsail Beach. The general impacts of these two activities are described below.

<u>General Environmental Consequences Related to Dredging</u>
The general environmental impacts of dredging include a direct temporary increase in turbidity within the water column. Excessive sediment loading increases turbidity and sedimentation, which can result in a decrease in biological productivity, clogging of fish gills, and reduced recruitment of invertebrates. Furthermore, turbidity can suppress SAV growth, cause low oxygen events leading to fish kills, and cause mortality of organisms in the bottom community, including oysters. Excavation of the new channel and the offshore borrow area is expected to result in temporary increases in suspended sediment and turbidity in the immediate area of construction activity. Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The low suspended sediment concentration combined with the low silt content of the Inlet and offshore borrow material resulted in the conclusion that turbidity should remain within the State Standards. Any increase in turbidity associated with the excavation of the channel or

offshore borrow area to the oceanfront shoreline should be of short duration. Natural conditions support fluctuating turbidity levels (9.7 to 35.2 Nephelometric Turbidity Units) in the nearshore and offshore water column of the Permit Area. These fluctuating turbidity levels would continue with or without the dredging efforts proposed with these alternatives. No cumulative effects are expected to occur from the dredging and placement activities. Turbidity would be anticipated to be elevated only immediately adjacent to the dredge operation and would only persist while dredging and the subsequent beach filling occurs. These short term direct impacts could result in the clogging of fish gills.

Dredging activity will also impact infaunal resources. Dredging results in a direct mortality of all organisms present within the dredged material (Posey and Alphin, 2002). Although the recruitment pattern is altered, the recovery of species after sediment removal is relatively quick, depending upon the opportunistic nature of the species (Street *et al*., 2005; Posey and Alphin, 2002). At dredge sites monitored off the coast of New Jersey, infaunal assemblages recovered within one year after disturbance, while biomass and taxonomic richness took 1.5 to 2.5 years to recover (Street *et al*., 2005; USACE, 2001). The diversity of micro and macrofauna tend to be dominated by opportunistic species that recover quickly when affected by natural causes (Mallin *et al*., 2000; Street *et al*., 2005; Posey and Alphin, 2002). Softbottom communities may also change with natural shifting patterns of sediment erosion or deposition (Street *et al*., 2005). Posey and Alphin (2002) suggests that effects of beach nourishment from dredging of an offshore borrow area is minimal compared to the natural variability of the system. Periodic use of the borrow areas for maintaining the South, Central, and North Sections would impact the softbottom habitat in the borrow area until the material is depleted, which could result in potential long-term direct impacts if the dredge site does not fill in. The periodic maintenance, except for Alternative 5 which is a one-time event, will allow for recovery of the habitat, however, there is a lack of research that identifies cumulative effects to offshore softbottom communities.

Dredging of the ocean bar channel at New River Inlet and nourishment of North Topsail Beach with dredged material from the ocean bar channel and offshore borrow area are scheduled to occur between November 16th and March 31st. The timing of construction activities was specifically scheduled to occur outside of the sea turtle nesting season, the West Indian manatee summer occurrence in North Carolina, the piping plover (and other shorebirds) migratory and breeding seasons, and the seabeach amaranth flowering period. Fish and larval biota which utilize the channel within the inlet are not anticipated to be impacted during dredging because the dredge will be positioned outside of the main channel utilized by these resources for ingress and egress from the inlet. Also, sand placement and dredge operation conducted outside of primary invertebrate production and recruitment periods (spring and fall) limit impacts to amphipods, polychaetes, crabs and clams.

A hydraulic cutterhead is proposed for dredging in the offshore borrow area and in the realigned ocean bar channel at New River Inlet. Compared to similar types of dredging methodologies, a cutterhead dredge creates minimal disturbance to the seafloor resulting in lower sedimentation and turbidity levels. Anchor (2003) conducted a literature review of suspended sediments from dredging activities. This report concluded that the use of a hydraulic dredge (i.e., cutter suction) limits the possibilities for resuspension of sediment to the point of extraction. Also, since the sediment is suctioned into the dredge head, the sediment cannot directly enter into the middle or upper water column. The utilization of a cutterhead dredge minimizes safety and navigational concerns due to the fact that the dredge will be well lit, stationary, and will include usage of buoys to mark the location of anchors.

No incidences of sea turtle takes from a hydraulic dredge have been identified during the research and development of this document. Therefore, the use and methods involved with this type of machinery reduces or eliminates the likelihood of an incidental take.

DREDGEPAK® or similar navigation and positioning software will be used by the contractor to accurately track the dredge location in relation to the hardbottom buffer protection zones. The software will provide real-time dredge positioning and digging functions to allow color display of dredge shape, physical feature data as found in background Computer Aided Design (CAD) charts and color contour matrix files from hydrographic data collection software described above on a leveroom Cathode Ray Tube (CRT) display. The software shall also provide a display of theoretical volume quantities removed during actual dredging operations.

General Environmental Consequences Related to Beach Fill

The placement of beach fill material will impact the infaunal resources found within the wet beach community as well as nesting turtles and nesting, resting, and foraging birds found along the dry beach community. The addition of beach fill to North Topsail Beach will cause short-term direct impacts to the adjacent wet beach community. Beach fill material will equilibrate offshore where it will, at least temporarily, bury the softbottom and wet beach community. Nelson (1985) indicates that organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels. This may support the reasoning for some organisms to withstand burial up to 10 cm. Other studies reported by Maurer (National Research Council, 1995) supported the burial capabilities of nearshore species, which found that these species are capable of burrowing through sand up to 40 cm. Although the wet beach infauna can adapt to fluctuations in the natural environment, the addition of sediment to the wet beach would have immediate, short-term negative impacts specifically in areas where beach fill will exceed 40 cm. Temporary burial of infaunal organisms could indirectly affect the birds and fish that forage on these organisms in the short and long-term. Negative cumulative effects

could occur if the diversity and abundance of infaunal populations do not recover between nourishment events, however no stretch of beach will be renourished generally within a 4 year period. Furthermore, the use of beach compatible material will increase the potential for rapid recovery.

Beach fill presents both positive and negative effects on nesting sea turtles. As a result of beach fill, the wider beaches in the Permit Area will benefit sea turtles since they require dry beaches to nest, preferring to nest along wide sloping beaches or near the base of the dunes. However, the composition, color, and grain size of the beach sand can affect the incubation time, sex, and hatching success of turtle hatchlings (Street *et al*., 2005). The wet and dry Munsell colors found on the native beach were compared by CPE geologists to the material identified in the Inlet borrow area and the offshore borrow area. The results of the comparison indicate that the color of the potential fill material is similar to the material currently found on the beach. The hue indicates only slight variations in the amount of red and yellow between the native and fill material. The native beach and fill chromas are within the same range; with the exception of two samples found in the Inlet borrow area. The fill material value is, on average, within one shade of the value of the native beach. The coarse section of the offshore borrow area and Inlet borrow area contain material with the lightest average value (6.0); followed by the native beach (5.5), and then the fine section of the offshore borrow area (4.5). The variations in color found between the fill sources and the native beach are not considered to be significant (Fadely and Larenas, pers. comm.). Therefore indirect effects to sea turtle nesting are not anticipated as a result of sand quality.

The grain size and color of the offshore borrow area material were analyzed and compared to the native sand. The grain sizes analyzed from the Inlet and offshore borrow areas were found to be compatible with the native beach sands (refer to Appendix B – Engineering Analysis; Appendix C – Geotechnical Investigations). Therefore, the project alternatives involving beach fill are not expected to negatively impact sea turtle nesting areas or the recovery of benthos along North Topsail Beach since the fill material is similar to that currently found on the native beach. The turbidity plume at the disposal end of the pipeline is not anticipated to increase well above ambient conditions due to the fact that the coarse grain size will allow for the rapid settlement compared to finer material. The increase in dry beach is also expected to positively affect the shorebirds, water birds and colonial birds that utilize this habitat. Several bird species utilize this habitat for roosting, foraging and nesting (refer to Section 4.2.3 for a description of bird species found on dry beaches).

Inlet Management Plan with Beach Nourishment Inlet Management Plan with Beach Nourishment

As stated earlier, the Permit Area for the project is based on the design as described under Alternative 3 and is identified as 1) a portion of the New River

Inlet complex that is likely to receive direct and indirect impacts from project construction and equilibration based on geotechnical evaluation and engineering models of the proposed alternatives, 2) 11.1 miles of oceanfront shoreline along North Topsail Beach that would receive fill material, 3) 2.0 miles of oceanfront shoreline along Onslow Beach that may undergo equilibration as a result of channel relocation activities, and 4) 966 acres of submerged lands at a site approximately 823 to 1,280 m (2,700 to 4,200 ft) from USACE Stations 800+00 to 880+00. The Permit Area is inclusive of all Alternatives boundaries.

5.3 PERMIT AREA HABITATS

The following sections correspond with the Permit Area habitats described in Section 4 and the potential qualitative and quantitative effects associated with each of the six chosen alternatives (Refer to Section 3.0 for a detailed description of each alternative).

5.3.1 ESTUARINE HABITATS

See Section 4.3.1 for description of estuarine habitats and the species that utilize the habitat.

5.3.1.1 SALT MARSH COMMUNITIES

Alternatives 1 and 2: No Action and Buy-Out/Relocation

Alternatives 1 and 2 are expected to have similar impacts on salt marsh communities as described below. Refer to Section 4.3.1.1 for a description of Salt Marsh Communities in the Permit Area.

Direct and Indirect Impacts. As described in Section 1.2, New River Inlet is a managed inlet and has been substantially altered by human activity. These activities include construction and maintenance of navigation channels, such as the AIWW and Cedar Bush Cut. The natural northeast transport of sand off North Topsail Beach into New River Inlet is approximately 270,000 cubic yards/year (cy/yr). As a result of this, the orientation of the ebb channel and the tidal prism of the Inlet are constantly changing and require continuous maintenance dredging of the inlet channel for navigation purposes. Most of the dredging in the bar channel is accomplished with government-owned side cast dredges while maintenance dredging in Cedar Bush Cut is performed by contract pipeline dredges. The material removed from the bar channel is cast to the side and allowed to settle through the water column whereas the Cedar Bush Cut material is deposited along the extreme north end of North Topsail Beach. Although the current maintenance effort is substantial, it rarely sustains the authorized channel dimensions for any length of time. Alternatives 1 and 2 would not alter the existing channel maintenance operations in the New River Inlet bar channel or the Cedar Bush Cut connecting channel, i.e., the past maintenance

practices by the USACE are assumed to continue. If either of these alternatives is chosen, the existing conditions are anticipated to remain the same.

Cumulative Effects. Natural erosion processes and littoral transport rates may continue removing sand from adjacent shorelines and depositing sediments into the inlet, in which further growth and development of inlet sand spits and shoals may result. As a result, the areas of low marsh (dominated by *Spartina alternaflora*) located specifically on the northwest side of the Inlet as well on the backside of Onslow Beach may become filled and transition into high marsh areas (dominated by *Spartina patens*).

Some areas, such as on Onslow Beach, may also experience breaches in the primary dune due to storms and high wave action, resulting in natural washover features which may extend into adjacent high salt marsh. These washover areas may cause the high marsh to become inundated and transition into low salt marsh over the long term, causing potential corresponding shifts in infaunal community composition, as well as shifts in finfish and bird community composition. Little is known about how resident species adapt to irregularly flooded marshes which are inundated for weeks at time. These resident species include, among other species, several types of fish (*e.g.*, killifish and mummichogs), brownwater snakes, crustaceans (various species of crabs), birds (yellowthroat, marsh wren, harrier, swamp sparrow, and five species of rails), and several species of mammals (nutria, cotton rat, and raccoon) (CCSP, 2009). These natural shifts in biological community composition would occur as an indirect, long-term impact. Although preliminary visual analysis of historical photographs as shown in the Engineering Analysis (Appendix B) resulted in no cumulative impacts to salt marshes, shoreline change calculations determined approximately 4 acres of high marsh would be naturally affected on the southern portion of Onslow Beach (Table 21) with both Alternatives 1 and 2. Beyond existing natural processes, no impacts are anticipated with Alternatives 1 and 2.

Alternatives 3 and 6: Inlet Management Plan with Beach Nourishment and Inlet Management Plan

Direct and Indirect Impacts. Erosion of the northeast shoreline of North Topsail Beach and of the southwest shoreline of Onslow Beach would be reduced with Alternative 3. Engineering model results for the proposed realignment of the Inlet bar channel do not indicate any significant changes to flow circulation patterns between the Inlet and the AIWW (See Appendix B - Engineering Analysis). As a result, short-term direct impacts to salt marsh communities within the estuarine system are not anticipated.

The construction of the new bar channel in New River Inlet and its subsequent maintenance every 4 years (48 months) is projected to eliminate the need for channel maintenance by the USACE for approximately 20 months following each operation. During the ensuing 28 months after each channel dredging operation

(initial construction and maintenance), shoaling of the channel will require some maintenance by the USACE, but USACE maintenance requirements should be at a lower level compared to existing conditions. While there may be some temporary increase in turbidity during initial construction of the new channel and the projected 4-year channel maintenance operations to reestablish the new channel position and alignment, the magnitude and significance of this effect is considered minor relative to existing conditions, which includes periodic sidecast dredging, due to 1) the relative position of salt marsh within the Permit Area, 2) adaptation to high ambient turbidity levels, 3) deposition of the dredged material on the beach rather than in the water column, and 4) exposure to tidal flushing. As shown in Section 6, vibracore samples collected from New River Inlet indicate that 1.15% of the material to be excavated will have a grain size of ≤0.0625 mm (silt). The silt content of native North Topsail Beach sand is 1.5% (see Appendix C -Geotechnical Investigations). Therefore, turbidity levels in the inlet during dredging operations will be temporarily elevated within proximity to the dredging and nourishment operations. However, due to the similar silt content of dredged material to the native beach material, the turbidity is expected to subside to ambient conditions immediately following dredging activities.

The disposal island to be utilized for incompatible material is situated in proximity to salt marsh resources. Erosion control measures, including improvements to the dike surrounding the upland disposal area, will be implemented to control material from eroding into adjacent salt marsh resources.

Like Alternative 3, erosion of the northeast shoreline of North Topsail Beach and the southwest shoreline of Onslow Beach would be reduced under Alternative 6. Engineering model results for the proposed modification of the Inlet bar channel do not show any significant impact on flow circulation patterns between the Inlet and the AIWW (See Appendix B—Engineering Analysis). As a result, no significant direct or indirect impacts on salt marsh communities associated with changes in flow patterns and circulation are anticipated. During construction, bird species foraging in the marsh may be temporarily displaced due to noise disturbance leading to direct impacts. Refer to Appendix B - Engineering Analysis.

Cumulative Effects. Periodic maintenance and realignment of the New River Inlet bar channel and nourishment of North Topsail Beach is expected to provide the shoreline and its residents both short and long-term shoreline storm protection with maintenance dredging of New River Inlet approximately every four years. This project objective may create a cumulative deficit of inorganic sediment accumulation in the back barrier low marsh habitat due to construction of a 14-foot NAVD dune plan on North Topsail Beach (Leonard, pers. comm.). Natural vertical accretion rates as high as 2.4 to 3.6 mm per year have been measured within salt marsh communities in North Carolina, however the maximum rate at which wetlands can accrete is not well understood (Craft e*t al.*, 1993). This estimated accretion rate may be decreased due to the sediment

deficit caused by the constructed dune system. Further, relative sea-level rise in North Carolina in recent years has ranged from approximately 1.8 to 4.3 mm per year at different points along the North Carolina coast (Zervas, 2004). Without this accumulation of sediment, the salt marsh habitat may subside and lose its important habitat value for species such as rails, bitterns, wading birds and marsh sparrows, several of which are species of conservation concern according to Partners in Flight (Hunter et al. 2001, Pashley et al. 2000, Rich et al. 2004 and Johns 2004). Other species which may be impacted include several types of fish (*e.g.*, killifish and mummichogs), brownwater snakes, crustaceans (various species of crabs), and several species of mammals (nutria, cotton rat, and raccoon) (CCSP, 2009). Additional subsidence due to increased rates of sea level rise also presents the problem of salt marsh subsidence in this area (Pearsall and Poulter, 2005). Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea-level. The historic rate of sea level rise is estimated to be 1.25 ft. per century, however this projection suggest the rate could double within the next 50 to 100 years (IPCC, 2007). Despite this, due to the continued flux of sediment through New River Inlet, the salt marsh will continue to receive sedimentation; therefore, significant cumulative impacts to the salt marsh community are not anticipated. Accretion along the northeast end of North Topsail Beach should occur within five years, with beach and ebb shoal equilibration occurring within 15 years following the Inlet relocation. The high salt marsh located behind the barrier dune system would continue to function as it has historically.

Shoreline erosion rates on Onslow Beach will likely be reduced but not eliminated. Realignment of the inlet is expected to result in a reconfiguration of the ebb tide delta with a large wedge of sediment located northeast of the new channel migrating onshore and merging with the extreme southwest end of Onslow Beach. The migration of this wedge of material could have a positive impact along the remainder of Onslow Beach. Cumulative effects are not expected to occur along the low and high marsh habitats located behind the barrier dune system.

Alternative 4: Beach Nourishment without the Relocation of the New River Inlet Bar Channel

Direct and Indirect Impacts. Erosion of the northeast shoreline of North Topsail Beach would be partially offset with the construction and subsequent nourishment of the 14-foot NAVD dune plan, however; erosion losses off of the beach fill along the north end are expected to be extremely high with most of the fill lost within two years following placement. The expected high rates of loss of the fill material from the north end could increase sediment transport into New River Inlet. Shoreline changes along the southwest shoreline of Onslow Beach would continue at historic rates. Construction of the 14-foot NAVD dune plan

along with periodic nourishment of the oceanfront shoreline may prevent natural overwash from occurring during storm events along most of the Town's shoreline; however, given the expected high rates of loss from the north end of the fill, this effect could be temporary on the northernmost 3,000 to 4,000 feet of the Town's shoreline.

The offshore borrow area material that would be used to construct and periodically nourish the project, particularly along the northern 12,000 feet of the project, has a smaller mean grain size and higher silt content than the material that would be removed from New River Inlet. As mentioned in Section 5.2, the higher silt content of the offshore material could increase suspended sediment and turbidity levels in the vicinity of New River Inlet above ambient conditions. The increased suspended sediment and turbidity levels should not have an indirect impact on marsh habitats, however limited direct impacts may be incurred due to the limited temporal nature of this potential disturbance. Turbidity would be anticipated to be elevated only immediately adjacent to the dredge operation and would only persist while dredging and the subsequent beach filling occurs. During construction, species foraging in the marsh may be temporarily displaced due to noise disturbance leading to direct impacts. Refer to Appendix B - Engineering Analysis.

Cumulative Effects. Alternative 4 may create a cumulative deficit of inorganic sediment accumulation in the back barrier low marsh habitat along most of North Topsail Beach due to construction of a 14-foot NAVD dune plan on North Topsail Beach and the reduction in overwash sediments during storm events. Like Alternative 3, natural vertical accretion rates as high as 2.4 to 3.6 mm per year have been measured within salt marsh communities in North Carolina, however the maximum rate at which wetlands can accrete is not well understood (Craft e*t al.*, 1993). This estimated accretion rate may be decreased due to the sediment deficit caused by the constructed dune system. However, due to the continued flux of sediment through New River Inlet, significant cumulative impacts to the salt marsh community are not anticipated.

Although preliminary visual analysis of historical photographs as shown in the Engineering Analysis (Appendix B) resulted in no cumulative impacts to salt marshes, shoreline change calculations determined approximately four acres of high marsh would be negatively affected on the southern portion of Onslow Beach (Table 21).

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas

Direct and Indirect Impacts. As mentioned in Section 5.2, periodic nourishment of the beach fill project using material from an offshore borrow area could cause temporary increases in suspended sediment and turbidity levels during these operations due to the higher silt content of the offshore material compared to the

inlet material. During construction, bird species foraging in the marsh may be temporarily displaced due to noise disturbance leading to direct impacts. Refer to Appendix B - Engineering Analysis.

Engineering model results for the proposed modification of the Inlet bar channel do not show any significant impact on flow circulation patterns between the inlet and the AIWW (refer to Appendix B—Engineering Analysis).

Cumulative Effects. A one-time realignment of the New River Inlet bar channel is expected to provide a temporary reduction in erosion rates along the extreme north end of North Topsail Beach with erosion rates retuning to existing rates within approximately 5 to 10 years. The one-time channel relocation could also slow erosion rates on the southwest end of Onslow Beach for a brief period with erosion rates returning to existing rates within 5 to 10 years.

Suspension of normal USACE channel maintenance activities in New River Inlet for approximately 20 months would provide a temporary respite to suspended sediment loads and turbidity levels associated with side cast dredge operations; however, the full resumption of normal channel maintenance by the USACE by year 4 following channel relocation would return suspended sediment and turbidity to existing levels.

As described with Alternatives 1-4, Alternative 5 may create a cumulative deficit of inorganic sediment accumulation in the back barrier low marsh habitat due to construction of a 14-foot NAVD dune plan on North Topsail Beach. Accretion along the northeast end of North Topsail Beach should occur within five years, after which, erosion rates are expected to return to existing rates as the channel migrates toward Onslow Beach. Periodic nourishment of the project using material from an offshore borrow area would result in higher suspended sediment loads and turbidity levels due to the higher silt content of the offshore borrow material. The high salt marsh located behind the barrier dune system would continue to function as it has historically.

The existing low and high salt marsh habitat within the back barrier of North Topsail Beach and Inlet complex would not be impacted in the short term; however, on a long-term basis, as mentioned above, due to the continued flux of sediment through New River Inlet, significant cumulative impacts to the salt marsh community are not anticipated.

Although preliminary visual analysis of historical photographs presented in the Engineering Analysis (Appendix B) resulted in no cumulative impacts to salt marshes, shoreline change calculations determined approximately four acres of high marsh to be negatively affected on the southern portion of Onslow Beach (Table 21).

5.3.1.2 SUBMERGED AQUATIC VEGETATION (SAV)

Alternatives 1, 2, and 4: No Action, Buy-Out/Relocation, and Beach Nourishment without the Relocation of the New River Inlet Bar Channel

Alternatives 1, 2, and 4 are expected to have similar impacts on SAV communities as described below.

Direct and Indirect Impacts. Although not depicted on existing resource maps, coordination with the National Marine Fisheries Service indicates the potential for small areas of SAV in the Permit Area. Refer to Section 4.3.1.2. Direct effects to these potential sites that could occur due to beach nourishment or USACE channel maintenance activities in New River Inlet and Cedar Bush Cut are not anticipated due to their location away from dredging activities.

Cumulative Effects. Occurrences of this resource within the Permit Area are not expected to incur cumulative impacts as these resources would naturally migrate to their preferred depth should sea levels rise over the next 30 years.

Alternatives 3 and 6: Inlet Management Plan with Beach Nourishment and Inlet Management Plan

Direct and Indirect Impacts. Although not depicted on existing resource maps, preliminary coordination with the National Marine Fisheries Service indicates the potential for small areas of SAV in the Permit Area (i.e. New River Inlet). Refer to Section 4.3.1.2. Direct effects as a result of dredging are not anticipated due to the remote location from these activities. Short-term indirect effects may occur as a result of increased light attenuation in the Inlet during construction and channel maintenance. However this disturbance will be temporary and is expected to have a lesser impact compared to existing channel maintenance activities via sidecast dredging. Furthermore, dredging activity would occur during winter months when SAV resources are biologically less active. The material to be dredged is relatively coarse and therefore will settle rapidly preventing prolonged elevated turbidity.

Cumulative Effects. Cumulative effects to SAV communities are not anticipated as a result of Alternatives 3 and 6 construction activities occurring in New River Inlet. Inlet maintenance dredging is expected to occur every 4 years. By maintaining the inlet, the need for regular sidecast dredging is expected to decrease.

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas

Direct and Indirect Impacts. Although not depicted on existing resource maps, preliminary coordination with the National Marine Fisheries Service indicates the

potential for small areas of SAV in the Permit Area (i.e. New River Inlet). Refer to Section 4.3.1.2. Direct effects as a result of dredging are not anticipated due to the remote location from these activities. Short-term indirect effects may occur as a result of increased light attenuation in the Inlet during construction. However this disturbance will be temporary and is expected to have a lesser impact compared to existing channel maintenance activities.

Cumulative Effects. Cumulative effects to SAV communities are not anticipated as a result of construction activities occurring in New River Inlet.

5.3.1.3 SHELLFISH HABITAT

Alternatives 1, 2, and 4: No Action, Buy-Out/Relocation, and Beach Nourishment without the Relocation of the New River Inlet Bar Channel

Alternatives 1, 2, and 4 are expected to have similar effects on shellfish habitats as described below.

Direct and Indirect Impacts. The North Carolina Division of Marine Fisheries (NCDMF) has mapped the general location of shellfish habitats. No shell bottom habitat is shown to occur near Cedar Bush Cut, the New River Inlet or near the shoreline of North Topsail Beach (Street *et al*., 2004), however DMF states that there is a possibility of shellfish resources to be present within the area.

Nevertheless, there is a possibility of shellfish areas occurring within the Permit Area.

Outside of existing conditions, no impacts to shellfish habitat are anticipated with Alternatives 1, 2, and 4.

Cumulative Effects. The shellfish habitats mapped by the NCDMF are located in the AIWW, Stump Sound and lower reaches of the New River Estuary. These areas are sufficiently distanced from the Permit Area and are sheltered by salt marsh and upland hammocks so as not to be affected by existing maintenance dredging activities.

Alternatives 3 and 6: Inlet Management Plan with Beach Nourishment and Inlet Management Plan

Direct and Indirect Impacts. The silt content of native beach sand on North Topsail Beach is 1.5% (see Appendix C -Geotechnical Investigations). Therefore, turbidity levels in the Inlet during dredging operations are likely to be below or consistent with ambient conditions. As a result, no significant impacts to potential shellfish habitats would occur as a result of hydrodynamic changes.

Furthermore, existing or potential shell bottom habitats are not known to exist in the area between New River Inlet and the AIWW (Street *et al*., 2004), therefore, Alternative 3 is not expected to impact existing or potential shell bottom habitats.

Cumulative Effects. The shellfish habitats mapped by the NCDMF are located in the AIWW, Stump Sound and lower reaches of the New River Estuary. These areas are sufficiently distanced from the Permit Area and are sheltered by salt marsh and upland hammocks so as not to be affected by proposed initial and maintenance dredging activities. Therefore, no cumulative impacts are anticipated.

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas

Direct and Indirect Impacts. Existing or potential shell bottom habitats are not known to exist in the area between New River Inlet and the AIWW (Street *et al*., 2004), therefore, Alternative 5 is not expected to impact existing or potential shell bottom habitats.

Cumulative Effects. The shellfish habitats mapped by the NCDMF are located in the AIWW, Stump Sound and lower reaches of the New River Estuary. These areas are sufficiently distanced from the Permit Area and are sheltered by salt marsh and upland hammocks so as not to be affected by existing or proposed initial or proposed channel dredging activities.

Alternative 6: Inlet Management Plan

Direct and Indirect Impacts. Existing or potential shell bottom habitats do not exist in the area between New River Inlet and the AIWW (Street *et al*., 2004), therefore, Alternative 6 is not expected to impact existing or potential shell bottom habitats.

Cumulative Effects. The shellfish habitats mapped by the NCDMF are located in the AIWW, Stump Sound and lower reaches of the New River Estuary. These areas are sufficiently distanced from the Permit Area and are sheltered by salt marsh and upland hammocks so as not to be affected by proposed channel dredging activities.

5.3.2 INLET COMPLEX

See Section 4.3.2 for description of Inlet complex habitats and the species that utilize the habitat.

5.3.2.1 UPLAND HAMMOCK

Alternatives 1 and 2: No Action and Buy-Out/Relocation

Direct and Indirect Impacts. Upland hammocks exist on the backside of Onslow Beach just north of New River Inlet and immediately adjacent to the seaward end of Cedar Bush Cut on the North Topsail Beach side of the inlet (Figure 8a, Section 4).

A continuation of the high rate of shoreline erosion on the southwest end of Onslow Beach could further weaken the existing dune system and increase the threat of saltwater intrusion associated with storm overwash episodes. On the North Topsail Beach side of New River Inlet, saltwater intrusion into the upland hammocks would occur primarily from storm surges overflowing the banks of Cedar Bush Cut as the upland hammocks are well removed from the ocean shoreline and are not normally affected by storm overwash from the ocean shoreline.

Cumulative Effects. Continuation of past shoreline changes along the southwest end of Onslow Beach could lead to increased instances of storm overwash and associated saltwater intrusion into the upland hammocks. This could result in approximately three acres of upland hammock habitat along the backside of Onslow Beach transitioning into an estuarine habitat (see Table 21). Continued erosion of the ocean shoreline on the North Topsail Beach side should not increase the threat of saltwater intrusion from the ocean side whereas saltwater intrusion from storm surges overflowing the banks of Cedar Bush Cut would continue to occur, especially in light of the predicted increases of sea level rise along the coast (IPCC, 2007).

A change in habitat would result in a direct impact to the flora and fauna that utilize the upland hammock habitat, such as the Eastern painted bunting, a high priority species. Historical data revealed that the Eastern painted bunting population decreased at least 3.5% annually over a 30 year period from 1966 to 1995 (refer to Section 4.3.2.1 for upland hammock community description).

Alternatives 3 and 6: Inlet Management Plan with Beach Nourishment and Inlet Management Plan

Direct and Indirect Impacts. Erosion of the northeast shoreline of North Topsail Beach would be reduced under Alternatives 3 and 6; however, since the primary threat of saltwater intrusion into the upland hammocks on the North Topsail Beach side of New River Inlet is from overflows from Cedar Bush Cut, a reduction in ocean shoreline erosion on North Topsail Beach would alter the direct or indirect impacts on the upland hammocks next to Cedar Bush Cut. The engineering model results for the proposed modification of the Inlet channel do not show any significant effect on tidal flow circulation patterns between the Inlet

and the AIWW (refer to Appendix B - Engineering Analysis). As a result, no direct or indirect impacts to upland hammock habitat are anticipated along North Topsail Beach as a result of project related changes in the hydrodynamics of New River Inlet.

Shoreline erosion rates along the southwest end of Onslow Beach should be reduced, but not eliminated, with the new channel position and alignment which could thereby reduce the threat of saltwater intrusion into the upland hammocks on the backside of Onslow Beach causing positive direct impacts.

Cumulative Effects. The reduction or elimination of the high rates of ocean shoreline erosion on the extreme north end of North Topsail Beach that are expected to occur with Alternative 3 would not have any cumulative impact on upland hammocks on the backside of North Topsail Beach. Alternative 3 should reduce but not eliminate shoreline erosion on Onslow Beach Realignment of the Inlet is expected to result in a reconfiguration of the ebb tide delta with a large wedge of sediment located northeast of the new channel migrating onshore and merging with the extreme southwest end of Onslow Beach. The onshore migration of this wedge of material could temporarily widen the beach and slow the rate of erosion, thus reducing the potential for storm overwash and associated saltwater intrusion into the existing upland hammocks, even in light of potential increases of the rate of sea level rise.

Alternative 4: Beach Nourishment without the Relocation of the New River Inlet Bar Channel

Direct and Indirect Impacts. Similar to Alternatives 1 and 2, the upland hammock habitats within the Inlet complex will continue to naturally erode, causing these habitats behind the dunes to be more susceptible to direct impacts from occasional saltwater intrusion. Based on preliminary visual analysis of historical photographs as depicted in the Engineering Analysis, no long-term impacts to salt marshes can be discerned (Appendix B). However, the shoreline change impact analysis determined approximately three acres of upland hammock habitat that would be affected over the long term along the backbarrier of Onslow Beach (see Table 21). Continued erosion of the shoreline and dunes will increase the potential for saltwater influx into the upland hammock, which would impact the biological community.

Cumulative Effects. Though initial beach nourishment would temporarily stabilize the shoreline, without realigning the Inlet channel, shoreline erosion rates along North Topsail Beach and Onslow Beach will remain unchanged. Erosion of dunes and beaches allows for upland hammock habitat in the back barrier to be more susceptible to saltwater influx, which could eventually lead to a transition from upland hammock to estuarine habitat. The shoreline change analysis determined that approximately three acres of upland hammock on the back barrier side of Onslow Beach would be negatively affected on the long term (see

Table 21). This would have a negative cumulative effect on the upland hammock community.

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and No Channel Maintenance

Direct and Indirect Impacts. A one-time Inlet relocation would provide immediate protection of the shoreline and would greatly reduce erosion in the Inlet complex. However, without periodic maintenance of the New River Inlet, it will likely migrate over time back to its current position, with erosion rates returning to current conditions. The predicted shoreline recovery for the northern end of North Topsail Beach associated with the Inlet Management Plan depends on the repeated relocation and alignment of the bar channel during the 30-year analysis period. Without repeated maintenance, the channel is expected to respond in a similar manner to its 1984 and 2003 orientation. That is, the channel should gradually migrate toward Onslow Beach. Accordingly, positive shoreline changes in the northern end of North Topsail Beach associated with the one-time channel relocation under Alternative 4 should be relatively minor and of a short duration (Engineering Analysis - Appendix B).

Cumulative Effects. Alternative 5 will have positive effects initially, however without regular Inlet maintenance this alternative would have negative cumulative impacts since the Inlet will return to its current position and erosion will continue. If erosion rates continue, existing shorelines in the Inlet complex may be susceptible to increased storm surge. Depending on the frequency and amount of flooding, upland hammocks could eventually transition from dry upland habitats to estuarine habitats. The shoreline change analysis determined approximately three acres of upland hammock on the back barrier side of Onslow Beach that would be negatively affected on the long term (30 years) (see Table 21).

5.3.2.2 INLET DUNES AND BEACHES

Alternatives 1 and 2: No Action and Buy-Out/Relocation

Direct and Indirect Impacts. Portions of the man-made and maintained dune system along the northern segment of North Topsail Beach have eroded and receded to the point where the primary dunes are now below or behind oceanfront homes located near the Inlet complex (refer to Appendix B - Engineering Analysis). Without Inlet management, the impacts of Alternatives 1 and 2 would include a continuation of shoreline erosion with the potential for long-term direct loss of dune resources in the Inlet complex of the Permit Area. For Alternatives 1 and 2, shoreline change rates along North Topsail Beach were determined using historical shoreline positions from 1983 to 2002 with a 3.6 ft/yr erosion rate along the northern fill section, 3.4 ft/yr erosion rate along the central fill section and 1.2 ft/yr erosion rate along the southern fill section. Refer to

Appendix B – Engineering Analysis. As the southern end of Onslow Beach, the undeveloped beach within the Inlet complex exists as a natural dune system. Shoreline change rates along the southern end of Onslow Beach were determined using historical shoreline positions from 1962 to 1984 (see Appendix B – Engineering Analysis) with an 18.2 ft/yr erosion rate (Table 21). Beyond existing natural processes, no impacts are anticipated with Alternatives 1 and 2.

The beach along the extreme north end of North Topsail Beach is presently scattered with abandoned homes and failed temporary sandbag revetments as well as exposed septic tanks and underground utilities. The existing condition of the beach on the north end of North Topsail Beach is not compatible to beach users as well as nesting sea turtles and nesting, resting, and foraging birds.

Cumulative Effects. As long as the ocean bar channel of New River Inlet remains oriented toward Onslow Beach, shoreline changes on both the north end of North Topsail Beach and the southern end of Onslow Beach observed over the past 24 years are expected to continue. Also, inlet-related shoreline erosion on North Topsail Beach is expected to migrate further south, encompassing more of the beach and dune system. The same is true on the Onslow Beach side as the inlet-related erosion is expected to affect more of the island north of New River Inlet. This will ultimately reduce important habitat for seabeach amaranth, nesting sea turtles and nesting, feeding, and foraging shorebirds.

Alternative 3: Inlet Management Plan with Beach Nourishment

Direct and Indirect Impacts. Natural erosion of the northeast shoreline of North Topsail Beach and the southwest shoreline of Onslow Beach would be reduced with Alternative 3 due to the repositioning of the inlet and the construction of the 14-foot dune plan and periodic beach nourishment. The proposed project will cause the dry beach between USACE baseline stations 1140+00 and 1160+00 to be widened seaward of existing structures thus creating suitable habitat for dune vegetation (Appendix B – Engineering Analysis). The wider sandy beach on the North Topsail Beach side will also dissipate the level of wave energy able to reach the dunes thus reducing the potential for dune erosion during storms. This increase in beach habitat will be beneficial to nesting sea turtles and birds utilizing the inlet beach for nesting, resting, and foraging. Wintering plovers on the Atlantic coast prefer wide beaches in the vicinity of inlets (Nicholls and Baldassarre, 1990; Wilkinson and Spinks, 1994). However, the development of the 14-foot dune will reduce the frequency of periodic overwash events which provide important habitat for seabeach amaranth and a number of water birds and shorebirds, including the federally threatened piping plover. According the Atlantic Coast Piping Plover Recovery Plan, nourishment of eroding beaches impedes overwash that would otherwise create and maintain ephemeral pools and bayside mudflats; preferred piping plover habitat. Tidal flats and ponds are important feeding areas to piping plovers at the start of the nesting season and at other times of the year (Fraser 2005). These areas are created during storm-

caused overwash and other erosional processes (Leatherman 1982), and beach stabilization efforts reduce the number and extent of these overwash events (Dean 1999). Beach stabilization, dune construction and disruption of natural processes (erosion, accretion, overwash, longshore transport, etc.) are listed as major contributing factors to the loss of suitable breeding and non-breeding habitat for colonial waterbirds (Hunter et al. 2006). Wintering plovers on the Atlantic coast prefer wide beaches in the vicinity of inlets (Nicholls and Baldassarre, 1990; Wilkinson and Spinks, 1994).

Significant widening of the beach on the Onslow Beach side is not anticipated, although some ephemeral widening could occur with the onshore migration of some of the abandoned ebb tide delta material lying off the southwest end of Onslow Beach.

Cumulative Effects. The repositioned inlet channel combined with the initial construction of the 14-foot dune plan followed by periodic nourishment should result in positive shoreline recovery along the extreme north end of North Topsail Beach over the first five years following channel relocation with essentially full recovery of the shoreline back to its 1984 condition within 15 years. This will be beneficial for nesting sea turtles which utilize the beaches. The wider beach will also provide positive effects for those engaging in recreational activities such as fishing, sunbathing, etc. The dune plan, however, is anticipated to reduce the frequency of storm induced overwash events. Overwash areas are important habitat for seabeach amaranth and a variety of birds, including the federally threatened piping plover. Natural shoreline erosion rates on Onslow Beach will likely be reduced but not eliminated. Realignment of the Inlet should result in a reconfiguration of the ebb tide delta with a large wedge of sediment located northeast of the new channel migrating onshore and merging with the extreme southwest end of Onslow Beach.

Alternative 4: Beach Nourishment without the Relocation of the New River Inlet Bar Channel

Direct and Indirect Impacts. The beach along the north end of North Topsail Beach near New River Inlet would be widened and an artificial dune constructed to an elevation of 14-feet NAVD using material from an offshore borrow area. The widened beach would provide a benefit to nesting sea turtles and birds as wintering plovers on the Atlantic coast prefer wide beaches in the vicinity of inlets (Nicholls and Baldassarre, 1990; Wilkinson and Spinks, 1994). While the constructed dune would provide storm protection, it would reduce the frequency of overwash events thereby reducing the extent of overwash habitat utilized by birds and seabeach amaranth. No beach or dune construction activities would take place on Onslow Beach.

Cumulative Effects. The inlet channel conditions that presently exist in New River Inlet which have been related to the high rates of erosion along the north

end of North Topsail Beach and the southwest end of Onslow Beach would persist. Accordingly, erosion losses from the 14-foot dune plan constructed along the extreme north end of the North Topsail Beach would be relatively high resulting in difficulty in maintaining a beach width adequate to protect the constructed dune. The overall reduction in frequency of overwash events would impact seabeach amaranth and birds which utilize overwash zones for foraging. Erosion impacts on the inlet beach and dune system along the southwest end of Onslow Beach would be the same as Alternatives 1 and 2.

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas

Direct and Indirect Impacts. Alternative 5 would have a short-term positive indirect effect on the inlet dunes and beaches on both sides of New River Inlet as the inlet and adjacent shorelines respond to the relocation of the New River Inlet bar channel. The wider beach will also provide positive effects for those engaging in recreational activities such as fishing and sunbathing. However, the inlet channel is expected to return to its current position and erosion along the northeast beaches and dunes on North Topsail Beach and along the southwest end of Onslow beach will resume at rates comparable to existing rates. Based on the Engineering Analysis (Appendix B), if the new channel responds similarly to its historical manner, shoreline recovery on the north end of North Topsail Beach would probably be limited to a five year period. This would provide a short term benefit to nesting sea turtles, seabeach amaranth, and nesting, resting, and foraging birds. Wintering plovers on the Atlantic coast prefer wide beaches in the vicinity of inlets (Nicholls and Baldassarre, 1990; Wilkinson and Spinks, 1994). After this initial five year period, however, the shoreline would begin to erode at rates comparable to the 1984 to 2003 period. Therefore, the assumed recovery over five years under Alternative 5 would be 35, 60, and 70 feet, for Reaches 114, 115, and 116, respectively. Following this five year recovery period, these shoreline reaches would again begin to erode at the same rates observed from 1984 to 2003. Erosion rates during this period were 5.9 ft/yr, 9.4 ft/yr, and 11.6 ft/yr for Reaches 114, 115, and 116, respectively. These erosion rates would negate the five year shoreline gains in all three reaches in approximately six years. See Engineering Analysis (Appendix B) for more information.

Cumulative Effects. Without periodic maintenance of the New River Inlet, the Inlet will return to its current position, which would again lead to erosion of the northeast beaches and dunes. Continued erosion of the shorelines will likely lead to a reduction in inlet dune and beach habitat for seabeach amaranth, nesting sea turtles, and nesting, resting, and foraging birds. Recreational opportunities will also be negatively impacted. Therefore Alternative 5 is expected to have negative cumulative impacts.

Alternative 6: Inlet Management Plan

Direct and Indirect Impacts. Erosion of the northeast shoreline of North Topsail Beach should be significantly reduced under Alternative 6. Based on the Engineering Analysis (Appendix B), initial construction of the beach fill using the inlet channel material combined with the periodic maintenance material from the inlet appears to be adequate to counter long-term shoreline losses but would not provide enough material to construct an artificial dune. Preventing long-term erosion would theoretically maintain the existing position of the shoreline over the 30-year analysis period; however, the relatively minor fill quantities would not provide any substantial protection to the existing manmade dune system near New River Inlet. Impacts to the dunes and beach on the southwest end of Onslow Beach would be similar to Alternative 3.

Cumulative Effects. The realignment and maintenance of the New River Inlet will have positive effects on the beaches near New River Inlet by reducing projected long-term (approximately 30 years) loss of beach habitat due to erosion. However, while the relatively increased beach width provided on North Topsail Beach would protect the existing dunes from erosion, the relative small amount of fill placement may not protect the beach and dunes from storms which would result in beneficial effects for birds utilizing overwash zones as foraging habitat.

5.3.2.3 INTERTIDAL FLATS AND SHOALS

Alternatives 1, 2, and 4: No Action, Buy-Out/Relocation, and Beach Nourishment without the Relocation of the New River Inlet Bar Channel

Direct and Indirect Impacts. The natural accumulation of sediments in the inlet complex may eventually cause sediment accretion on the flats and shoals. Existing intertidal flats and shoals may become supratidal. This change in habitat may alter infauna community composition, which may in turn alter the finfish and bird communities that feed on them. However, the unconsolidated and unvegetated communities that occur in the inlet complex would continue to be naturally redistributed. Unconsolidated communities lack structure and are dynamic in nature. Periodic storms and seasonal climatic changes influence abundance and diversity of micro- and macrofauna, tending toward a more opportunistic community (Mallin *et al*., 2000; Street *et al*., 2005).

The USACE is expected to continue to maintain the authorized navigation channels in New River Inlet and Cedar Bush Cut as well as at the intersection of Cedar Bush Cut with the AIWW. The USACE side cast dredging efforts in the New River Inlet bar channel deposits material through the water column on the sides of the channel, and has the potential to temporarily increase suspended sediment loads and turbidity. These periodic maintenance dredging events are conducted within the deep water sections of the channel and follow the natural thalwag, thereby avoiding existing shoals. During flood stages of the tidal cycle,

dredged material that remains in suspension could be transported into the interior portions of the inlet complex and settle on the intertidal flats and shoals. However, the material shoaling the New River Inlet bar channel has a low silt content, and is fairly coarse, will result in only minor and ephemeral increases in both suspended sediment and turbidity. Maintenance dredging in Cedar Bush Cut and the intersection of Cedar Bush Cut with the AIWW is normally accomplished with contract pipeline dredges with disposal of the shoal material on the north end of North Topsail Beach. Shoal material in Cedar Bush Cut and the AIWW has a smaller grain size than material shoaling the inlet bar channel; however, only minor increases in suspended sediment and turbidity occur at the point where the cutterhead of the dredge interacts with the bottom and at the point of discharge on the beach.

Alternatives 1, 2, and 4 are expected to have no direct impacts on intertidal flats and shoals but could have minor secondary impacts due to maintenance dredging-related increases in suspended sediment and turbidity which could be transported to the interior of the inlet complex during flood stages of the tidal cycle. The intertidal flat biotic community's density and abundance may fluctuate over time, but overall would remain persistent. Beyond existing natural processes and the effects of navigation channel maintenance activities, no additional impacts are anticipated with Alternatives 1, 2, and 4.

Cumulative Effects.
Outside of natural processes, continuation of the navigation channel maintenance activities has the potential to increase suspended sediment loads and turbidity transported into the interior portions of the inlet complex during flood tidal stages. These impacts are considered to minor and well within normal fluctuations associated with natural events such as storms.

Alternatives 3 and 6: Inlet Management Plan with Beach Nourishment and Inlet Management Plan

Direct and Indirect Impacts. These alternatives will directly remove a portion of the ebb tide delta that presently lies at or just below mean low water via cutterhead dredging. Removal of approximately 45 acres of the existing ebb shoal system will be semi-permanent as a result of future channel maintenance operations that will be necessary to keep the channel in the favorable position and along the preferred alignment. The ebb tide delta is expected to reform during the estimated four-year interval between channel re-alignment and maintenance events. The reformation of the ebb tide delta will include the onshore migration of a sediment wedge presently situated off the southwest end of Onslow Beach. Although portions of the ebb tide delta will be removed, the natural migration of the intertidal flats and shoals within the inlet complex is expected as a result of the dynamic nature of the tidal inlet and is anticipated to continue to persist within the permit area due to its dynamic nature. Following

the construction of the new inlet channel, it is anticipated that the pre-construction inlet channel will fill in within several months.

Studies of dredging and disposal effects on nearshore or estuarine fish populations have reported rapid recovery or minimal effects (Courtenay *et al.*, 1980; de Groot, 1979a; de Groot, 1979b; Posey and Alphin, 2000). Topographic changes in certain borrow areas have also shown to positively affect certain fish by creating refuge or forage areas (Lalancette, 1984).

As mentioned in Section 5.2, there is the potential for temporary increases in turbidity associated with dredging in the Inlet and subsequent maintenance events. The magnitude and significance of this effect is considered minor and short term due to the relative position of intertidal flats within the Permit Area, adaptation to ambient turbidity levels, disposal of the dredged material on the beach rather than through the water column, and exposure to tidal flushing.

Cumulative Effects. Cumulative effects from increased turbidity levels on intertidal flats and shoals are not anticipated since the effects will be short-term during construction. Due to the dynamic nature of the ebb tide delta and associated shoals and flat within New River Inlet, it is anticipated that there will be no net loss of these habitats within the inlet complex despite the implementation of the Inlet Management Plan due to the natural infilling of the pre-construction inlet channel within months of the dredging of the new inlet channel.

The repositioned inlet should result in shoreline recovery along a majority of North Topsail Beach, with accretion occurring within five years after construction. Equilibrium of the oceanfront shoreline with the ebb shoal should occur within 15 years following the Inlet relocation. Shoreline erosion rates on Onslow Beach will likely be reduced but not eliminated. Realignment of the Inlet should result in a reconfiguration of the ebb tide delta with a large wedge of sediment located northeast of the new channel migrating onshore and merging with the extreme southwest end of Onslow Beach. The migration of this wedge of material could have a positive impact to inlet shoals along the remainder of Onslow Beach. Refer to Appendix B - Engineering Analysis.

Periodic maintenance of New River Inlet and nourishment of North Topsail Beach within the vicinity of the inlet is expected to provide the shoreline and its resident's long-term shoreline protection for storm protection. The cumulative effect of dredging on the shoaling habitat is a short-term, negative, direct impact resulting in the mortality of those infaunal species not adapted to avoidance of burial at the fill site and entrainment from the borrow area resulting from dredging operations. Research indicates that infaunal populations recover within 2 to 6.5 months after completion of nourishment projects (Burlas *et al*., 2001). The infaunal community composition and abundance could be impacted by the

periodic maintenance of New River Inlet, which in turn could affect the finfish, birds and other organisms that utilize this habitat for shelter and foraging.

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas

Direct and Indirect Impacts. Alternative 5 will effect a one-time removal of a portion of the ebb tide delta that presently lies at or just below mean low water. Like Alternatives 3 and 6, the new channel should precipitate reformation of the ebb tide delta on the south side of the inlet and onshore migration of the wedge of sediment lying off the southwest end of Onslow Beach. Ebb tide delta reformation is expected to be short lived as the new channel is predicted to shoal completely and/or begin to migrate to an unfavorable position and alignment within 4 years following construction. USACE channel maintenance in the bar channel could be suspended for 20 to 24 months but would resume once the controlling depths in the channel become less than 6 feet below mean low water as authorized. By year 4 following construction, USACE maintenance dredging requirements is expected to return to levels comparable to existing conditions. There is a potential for temporary increases in turbidity associated with the one-time relocation of the channel, however, the magnitude and significance of this effect is considered minor due to the relative position of intertidal flats within the Permit Area, adaptation to ambient turbidity levels, disposal of the dredged material during construction on the beach rather than through the water column, and exposure to tidal flushing. Turbidity and suspended sediment loads in New River Inlet would return to existing conditions soon after construction activities.

Dredging of the inlet sediments would also directly impact the infaunal community due to removal. In addition, a change in infaunal community composition may affect the finfish and bird communities that feed on them. However, as described above, the infaunal communities are highly resilient and are anticipated to recover within months following their initial disturbance.

Cumulative Effects. Due to the relative rapid recovery of the infaunal communities, the one-time realignment of the inlet bar channel and the utilization of offshore borrow areas, limited cumulative impacts to the infaunal communities utilizing the intertidal flats and shoals will occur. In order to meet nourishment volume needs through all 5 phases, Alternative 5 will utilize more material (and subsequently a greater footprint) from the offshore borrow areas compared to Alternative 3. This will result in a larger area disturbed within the offshore borrow area.

5.3.3 COASTAL BEACH AND DUNE HABITATS

See Section 4.3.2.4 for description of beach and dune habitats and the species that utilize the habitat.

5.3.3.1 DUNE COMMUNITIES

Alternatives 1 and 2: No Action and Buy-Out/Relocation

The impacts of Alternatives 1 and 2 on oceanfront dune communities would be essentially the same as described below.

Direct and Indirect Impacts. Without Inlet management and/or beach nourishment, the long-term indirect impacts of Alternatives 1 and 2 would include a continuation of natural shoreline changes in the Permit Area. These changes include the natural erosion and accretion of coastal dunes. Based on the Geotechnical Investigations (Appendix C), the maintained dune communities on North Topsail Beach in their current condition, average height of 10 to 12 feet, are expected to erode. As a result, the dune community in this area is expected to be highly susceptible to regular storm events. Currently, high tides extend beyond the first line of oceanfront structures on the north end of North Topsail Beach. Without repositioning the Inlet and/or widening the beaches, the dunes of North Topsail and Onslow Beaches will continue to be exposed and erode. Continued erosion will impact dune vegetation, resulting in a degraded habitat used by several species of roosting, foraging and nesting shorebirds and plant species, such as seabeach amaranth (refer to Section 4.3.3 for a description of dune communities in the Permit Area). Alternatives 1 and 2 are expected to have direct and indirect impacts to dune communities with approximately one acre of dune habitat on North Topsail Beach and 35 acres on Onslow Beach to be negatively impacted (Table 21) by either Alternatives 1 or 2. These acreage estimates are derived from modeling outputs and it should be noted that these figures are subject to variation. Outside of existing natural processes no impacts are anticipated with Alternatives 1 and 2.

Cumulative Effects. Although the dune communities within the Permit Areas are dynamic, modeling results suggest that without repositioning the Inlet and/or widening the beaches, the dunes of North Topsail and Onslow Beaches will continue to be exposed and erode. Continued erosion will impact dune vegetation resulting in a degraded habitat used by several species of roosting, foraging and nesting shorebirds and plant species, such as seabeach amaranth. Therefore, Alternatives 1 and 2 are expected to have negative long-term cumulative impacts.

Seabeach amaranth, a Federal and State listed species, is a ‘fugitive’ species which grows on barrier island beaches in recently disturbed by storms or beach nourishment. It prefers overwash flats at accreting ends of islands and lower foredunes and upper strands of non-eroding beaches; these preferred habitats are located on both sides of the New River Inlet. It does not compete well with other dune vegetation which supports a positive association with beach nourishment projects (NCFWS, 2006). In the central and southern reaches of the Permit Area the dune system is moderately vegetated and marginally stable.

The predicted increase in rates of sea level rise (IPCC, 2007) will potentially threaten the long term viability of dunes within the permit area as storm surges could degrade these resources.

Alternative 3: Inlet Management Plan with Beach Nourishment

Direct and Indirect Impacts. The beach nourishment, dune restoration and inlet management plan included in Alternative 3 would positively impact the dune systems along North Topsail Beach over the long-term (30 years). Man-made dunes are found along the entire oceanfront shoreline of North Topsail Beach.

The dune plan would rebuild dunes in the North and Central sections of the oceanfront shoreline on North Topsail Beach to a height of 14 feet (NAVD), where deemed necessary by the on-site Construction Engineer. As described in the Engineering Analysis (Appendix B), select fill areas located landward of hardbottom outcroppings, approximately 350 m (1,150 ft) offshore of the February-March 2002 mean high water line, have been designed with a reduced berm width. A 17 m (57 ft) berm width has been applied to the north fill area design, located between USACE baseline stations 1020+00 to 1160+00, to avoid coverage of nearshore hardbottom. Similarly, a 14.6 m (48 ft) berm width has been designed for the fill area between USACE baseline stations 840+00 to 900+00 in the Central section, to receive coarse material from the offshore borrow area. The reduction in the designed berm width is a result of using coarser grain size material that is more resistant to erosional processes compared to finer grained material, resulting in a perched beach.

Reinforcing North Topsail Beach will stabilize the dune system and provide long-term storm protection. These stabilization measures will allow for growth and development of dune vegetation and provide habitat for roosting, foraging and nesting shorebirds. Alternative 3 is expected to have positive direct and indirect impacts to dune communities on North Topsail Beach.

The southwestern segment of Onslow Beach (near the Inlet) was, at one point in time, absent of dune ridges (Cleary, 1999). However as recently as August 2006, CPE marine biologists observed small dune features in this area during ingress and egress through the Inlet (Hague, pers. comm.). The sediment budget with the inlet management plan would, in the absence of artificial bypassing of sediment from the inlet to Onslow Beach, increase the deficit on the south end of Onslow Beach from 97,000 cubic yards/year to 121,000 cubic yards/year. With this amount of sediment deficit in mind, shoreline impact calculations determined approximately 14 acres of dune habitat within the Permit Area to be negatively impacted on Onslow Beach.

Cumulative Effects. The repositioned Inlet and addition of beach fill should result in shoreline recovery along a majority of North Topsail Beach, with accretion on northeast beaches occurring in approximately five years after construction,

however it is expected to result in continued erosion along Onslow Beach. Periodic maintenance of New River Inlet and nourishment of North Topsail Beach is expected to provide the shoreline and its resident's long-term shoreline protection. Beach nourishment and inlet management are expected to stabilize and protect dune systems in the long-term, thus resulting in positive cumulative effects on North Topsail Beach. Based on the shoreline change analysis, Onslow Beach dune communities will be negatively impacted (approximately 14 acres) (Table 21).

Alternative 4: Beach Nourishment without the Relocation of the New River Inlet Bar Channel

Direct and Indirect Impacts. Over the course of the 30 year project period, a total of 9,002,781 cubic yards of material would be needed to maintain the 14-foot dune plan in the Central and North Sections. This could provide long term protection to the ocean front. In the absence of the Inlet Management Plan, all periodic nourishment material would have to be obtained from offshore borrow sources or upland borrow pits. The volume of material needed to construct the 14-foot Dune Plan in the Central and North Sections totals about 3.8 million cubic yards. Accordingly, the number of truck loads required to construct the project would be around 223,500. If the project was constructed over two construction periods, approximately 210 trailer dump trucks would be needed.

Initial construction of Alternative 4 would deplete all presently known sources of coarse grain material in the offshore borrow area. Accordingly, additional offshore sand sources would be needed to nourish the fill areas adjacent to hardbottom resources to avoid direct and indirect impacts to these resources. Similar to Alternative 3, select fill areas landward of hardbottom resources have been designed with a reduced berm width to avoid impacts to these resources.

The direct impact of this alternative on dune communities on North Topsail Beach will be positive, due to the greater beach width and the restored 14-foot (NAVD) dune heights. However without realignment of the New River Inlet channel the beaches and dunes are expected to continue to erode. Continued erosion is expected to result in approximately 35 acre loss of dune communities along Onslow Beach (over a 30 year period, see Table 21). Reduction of the dune system will affect the vegetation that provides habitat to several species of roosting, foraging and nesting shorebirds (refer to Section 4.3.3 for a description of dune communities in the Permit Area).

Cumulative Effects. Nourishment along the North, Central and South sections of North Topsail Beach may provide some temporary reduction in storm damage; however, the oceanfront portion along the north end of North Topsail Beach and the southern end of Onslow Beach will still experience significant long-term erosion. Without realignment of the New River Inlet, erosion will persist along the shoreline in the Permit Area and dune systems will continue to erode and recede.

Therefore, long term cumulative effects from Alternative 4 closer to the inlet will be negative.

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas

Direct and Indirect Impacts. Like Alternative 3, beach nourishment combined with realigning New River Inlet channel will initially have a positive impact on the shoreline and dune system, providing protection against beach and dune erosion for the entire oceanfront shoreline of North Topsail Beach. However, without long-term repeated maintenance, the Inlet would most likely behave in a manner similar to that which occurred between 1984 and 2003, in which it should gradually migrate to an orientation toward Onslow Beach. Consequently, the erosion rates on Onslow Beach will be similar to those occurring under Alternative 3. Positive shoreline changes observed after the one-time Inlet relocation would be relatively minor and of a short duration. Alternative 3 would be expected to lead to an ebb shoal equilibrium in 15 years, whereas Alternative 5 shoreline equilibrium between the northeast shoreline and the ebb shoal may not be reached. The northeast oceanfront shoreline would return to erosion rates comparable to the 1984 to 2003 period, resulting in negative impacts to the dune communities. Similar to Alternative 4, the shoreline change analysis determined approximately 35 acres of dune communities along Onslow Beach to be eroded over a 30 year period. These erosion rates would eliminate the five year shoreline gains in all three reaches in approximately six years (refer to Appendix B - Engineering Analysis).

Cumulative Effects. Nourishment along the Central and South Sections of North Topsail Beach is expected to provide long-term reduction in storm damage; however the north end of North Topsail Beach and the south end of Onslow Beach will still experience significant erosion. Without continued maintenance of the New River Inlet channel, the main ebb channel will likely return to its current position, resulting in erosion along the oceanfront shoreline and a further reduction in dune habitat. Therefore, Alternative 5 is expected to have negative cumulative impacts to dune communities closest to the inlet.

Alternative 6: Inlet Management Plan

Direct and Indirect Impacts. Initial construction of the beach fill area using the Inlet channel material, combined with the periodic maintenance will have some positive effect on the northeast North Topsail Beach dune system. Preventing long-term erosion at the northeast end would maintain the existing position of the shoreline over the 30-year analysis period. However, the relatively minor fill quantities would not provide substantial storm protection along the remaining North and Central Sections. This plan does not include dune restoration. Like Alternative 3, the shoreline change analysis determined approximately 14 acres of dune community habitat on Onslow Beach to be eroded over a 30 year period.

Cumulative Effects. The realignment and maintenance of the New River Inlet channel and the nourishment of North Topsail Beach will help protect against long-term erosion. However, using only the material obtained from inlet maintenance for periodic beach maintenance will not provide enough material to protect against substantial storm damage. As a result, the dune systems would still be exposed to erosion from storm damage (refer to Appendix B - Engineering Analysis). Storm damage will still cause dune erosion and recession in the Permit Area, leading to negative cumulative effects on dune vegetation and birds that use dune habitats for roosting, foraging and nesting (refer to Section 4.3.3 for a description of the dune communities).

5.3.3.2 DRY BEACH COMMUNITIES

Alternatives 1 and 2: No Action and Buy-Out/Relocation

The impacts of Alternatives 1 and 2 on dry beach communities is expected to be essentially the same as described below.

Direct and Indirect Impacts. The dry beach area is a high energy area that does not support much vegetation; however this habitat is utilized by several species of sea turtles and shorebirds. Beaches, as well as inshore and offshore waters, along the Atlantic Coast of the United States are important foraging and developmental habitats for many of the threatened and endangered species of sea turtles (Shoop and Kenney, 1992; Ehrhart, 1983; Keinath et al., 1987); which could include the oceanfront shoreline of North Topsail Beach. Although sea turtles are continuing to nest along the oceanfront shoreline of North Topsail Beach, the number of nests would be reduced due to the loss of suitable dry nesting beach habitat. Whereas the survival rate of hatchlings could be reduced from possible inundation of encroaching mean high water marks through severe erosion.

Alternatives 1 and 2 would have a negative direct short- and long-term impact on the dry beach communities in the Permit Area. Without repositioning the New River Inlet channel or nourishing the beaches with additional material, natural shoreline erosion will continue and will reduce the available dry beach area. Based on the shoreline change analyses for Alternatives 1 and 2, approximately 33 acres of dry beach habitat would be lost on North Topsail Beach. Approximately 29 acres of dry beach habitat would be lost on Onslow Beach within the Permit Area (Table 21). Alternatives 1 and 2 would allow the dry beach to continue to erode, reducing available habitat for sea turtles and birds along the 11.1 miles of oceanfront shoreline of North Topsail Beach. These alternatives result in short- and long-term direct and indirect impacts.

Cumulative Effects. With Alternatives 1 and 2, the erosion of the North Topsail and Onslow Beach shorelines is expected to continue, resulting in net loss of dry

beach habitat. Therefore Alternatives 1 and 2 are expected to have negative cumulative impacts.

Alternative 3: Inlet Management Plan with Beach Nourishment

Direct and Indirect Impacts. The beach nourishment, dune restoration and Inlet management plan included in Alternative 3 would positively impact the dry beach communities along North Topsail Beach through the expansion of the dry beach. Beach nourishment would restore North Topsail Beach's shoreline, and Inlet channel realignment would initiate natural accretion along the northeast dry beaches. While Alternative 3 is not expected to stop erosion along Onslow Beach it is anticipated to slow the current recession rate. Based on the shoreline change analysis, approximately 22 acres of dry beach habitat will be reduced on Onslow Beach, as a result of erosion over a period of 30 years (Table 21).

Repositioning New River Inlet and nourishing North Topsail Beach will stabilize the shoreline and lead to accretion of the dry beach along the northeast end of North Topsail Beach, enlarging the available dry beach habitat. As mentioned in Section 5.2, wider beaches in the Permit Area will benefit sea turtles since they require dry beaches to nest, preferring to nest along wide sloping beaches or near the base of the dunes. However, the composition, color, and grain size of the beach sand can affect the incubation time, sex, and hatching success of turtle hatchlings (Street *et al*., 2005). According to Greene (2002), beach nourishment can benefit endangered and threatened sea turtles by restoring habitat along eroded beaches. Some studies have found no significant difference between nourished and non-nourished beaches in the number of eggs per nest, as well as, hatching and emergence success (Nelson *et al*., 1985; Ryder, 1991). Other projects have shown increased numbers of nests, hatchlings, and survival rate of young turtles (Raymond, 1984).

The increase in dry beach along North Topsail Beach is also expected to positively affect the shorebirds, water birds and colonial birds that utilize this habitat. But negatively could impact these resources along Onslow Beach. Several bird species utilize this habitat for roosting, foraging and nesting. Reduction of dry beach habitat may negatively affect sea turtle nesting (refer to Section 4.2.1 for description of sea turtles) and the habitat utilized by several species of roosting, foraging and nesting shorebirds (refer to Section 4.2.3 for information on bird species that occur along the dry beaches of the Permit Area).

Cumulative Effects. The repositioned Inlet and addition of beach fill should result in shoreline recovery along a majority of North Topsail Beach, with accretion occurring on the northeast end approximately five years after construction. Equilibrium of the northeast shoreline with the ebb shoal should occur within 15 years following the Inlet relocation. Shoreline erosion rates on Onslow Beach will likely be reduced compared to those anticipated in Alternatives 1 and 2; however erosion rates will not be completely eliminated. Unlike in Alternatives 1 and 2,

the realignment of the Inlet channel should result in a reconfiguration of the ebb tide delta with a large wedge of sediment located northeast of the new channel migrating onshore and merging with the extreme southwest end of Onslow Beach. The migration of this wedge of material could have a positive impact along the remainder of Onslow Beach (Refer to Appendix B - Engineering Analysis). This process will account for the difference anticipated between this alternative and Alternatives 1 and 2.

Alternative 4: Beach Nourishment without the Relocation of the New River Inlet Bar Channel

Direct and Indirect Impacts. The design approach of Alternative 4 on the dry beach along the North Topsail Beach oceanfront shoreline will also be wider, similar to Alternative 3. Without the additional coarse material available from the Inlet, assumptions for this alternative include identifying a sufficient amount of beach compatible material to supplement the beach fill design. The immediate direct impact of this alternative on dry beach habitat would be positive on North Topsail Beach resulting in no loss of habitat over 30 years, due to the greater beach width and the restored 14 foot (NAVD) dune heights. According to Greene (2002), beach nourishment can benefit endangered and threatened sea turtles by restoring habitat along eroded beaches. Some studies have found no significant difference between nourished and non-nourished beaches in the number of eggs per nest, as well as, hatching and emergence success (Nelson *et al*., 1985; Ryder, 1991). Other projects have shown increased numbers of nests, hatchlings, and survival rate of young turtles (Raymond, 1984).

However, without the Inlet management plan, the north end of North Topsail Beach will continue to be exposed to greater wave energy leading to more erosion along North Topsail Beach. As a result, the northeast oceanfront shoreline immediately adjacent to the inlet is expected to continue to erode, similar to the results of the August 2006 USACE navigation and disposal project on the north end of North Topsail Beach (Sugg, pers. comm.). This may lead to a negative long-term impact on dry beach communities along this section of North Topsail Beach.

Although the shoreline change analysis calculated no net loss of dry beach habitat for North Topsail Beach, approximately 29 acres will be reduced on the southern end of Onslow Beach (Table 21). Reduction of dry beach habitat may negatively affect sea turtle nesting (refer to Section 4.2.1 for description of sea turtles) and the habitat utilized by several species of roosting, foraging and nesting shorebirds (refer to Section 4.2.3 for information on bird species that occur along the dry beaches of the Permit Area).

Cumulative Effects. Subsequent periodic nourishment of the beach in the North and Central Sections will either come from an offshore borrow area(s), upland source(s), or a combination of offshore and upland source(s). Without the

recovery of the shoreline just south of New River Inlet, sediment losses from the north end of the fill will occur at a high rate resulting in reduced beach widths between periodic nourishment. The continued erosion along North Topsail Beach and Onslow Beach will allow dune systems and the shoreline in proximity to the inlet to continue to recede and erode (refer to Appendix B - Engineering Analysis). Although infaunal resources along the beach will be disturbed on a regular basis every four (4) years, minimal cumulative effects will be incurred as these resources are known to recover rapidly within an order of several months.

Nourishment of the North, Central and South Sections of North Topsail Beach may provide some temporary reduction in storm damage; however overall, both North Topsail and Onslow Beaches near the inlet will still experience significant erosion. Erosion will persist along the shoreline in the Permit Area and dry beach will continue to erode and recede due to the current orientation of the inlet. Therefore, cumulative effects from Alternative 4 on the northeast end of North Topsail Beach will be negative.

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas

Direct and Indirect Impacts. Since the New River Inlet bar channel would only be relocated once, material from maintenance of the inlet channel would not be available for periodic nourishment. Accordingly, periodic nourishment material would have to come from either an offshore borrow source or inland source. Since initial construction would remove all coarse grain material from the offshore borrow area, periodic nourishment costs for Alternative 5 would be essentially the same as Alternative 4 including the additional sand search costs.

Aligning the New River Inlet entrance bar channel to a position perpendicular to the shoreline will initially have a positive, indirect impact on the shoreline, similar to Alternative 4. This would result in a reduced erosion rate to the beach and dune habitats and an increased dry beach habitat. This Alternative will provide a wider dry beach along the entire 11.1 miles than is currently available. However, with only a single relocation dredging event, the Inlet would most likely behave in a manner similar to that which occurred between 1984 and 2003 in which it should gradually migrate to an orientation toward Onslow Beach. Positive shoreline changes observed after the one-time Inlet relocation would be relatively minor and of a short duration.

Alternative 5 shoreline stabilization of the northeast end of North Topsail Beach would probably be limited to a five year period or less. After which time, the oceanfront shoreline would begin to erode at rates comparable to the 1984 to 2003 period, resulting in negative impacts to the beach and dune communities. Similar to Alternative 4, the shoreline change analysis determined no net loss of dry beach habitat for North Topsail Beach. However, approximately 29 acres of dry beach habitat will be lost on the southern end of Onslow Beach (Table 21).

These erosion rates would eliminate the five year shoreline gains in all three reaches in approximately six years (refer to Appendix B - Engineering Analysis). A return to shoreline erosion in the Permit Area would again reduce dry beach habitat that is utilized by several sea turtle and bird species.

Cumulative Effects. Nourishment of the North, Central and South Sections of North Topsail Beach and one-time realignment of the New River Inlet channel would provide some temporary reduction in storm damage and increase in dry beach habitat. However, both North Topsail and Onslow Beaches near the inlet will still experience significant erosion over the long-term. With only a one-time relocation event of the New River Inlet channel without maintenance it will likely return to its current position, leading to erosion along the shoreline in the Permit Area and further reduction in dry beach habitat. Therefore, Alternative 5 is expected to have negative cumulative impacts at the northeast end of North Topsail Beach as important habitat is lost for nesting sea turtles and bird species.

Alternative 6: Inlet Management Plan

Direct and Indirect Impacts. This alternative includes realigning the New River Inlet entrance channel and distributing the dredged inlet material along the entire 37,500 feet of ocean shoreline within the North and Central Sections of North Topsail Beach. Based on the Engineering Analysis (Appendix B) initial construction of the dry beach fill using the inlet channel material combined with the periodic maintenance material from the inlet appears to be adequate to counter long-term shoreline losses. Preventing long-term erosion would theoretically maintain the existing position of the shoreline over the 30-year analysis period; however, the relatively minor fill quantities would not provide any substantial storm protection.

Periodic Inlet channel maintenance would provide some beach fill resulting in some shoreline protection to the North and Central Sections. Preventing long-term erosion would maintain the existing position of the northeast shoreline and subsequently the dry beach over the 15-year analysis period; however, the relatively minor fill quantities would not provide substantial fill volumes for adequate storm protection. Similar to Alternative 3, the shoreline change analysis determined approximately 22 acres of dry beach habitat will be reduced on Onslow Beach, as a result of erosion over a period of 30 years (Table 21).

Initial construction of the beach using the Inlet channel material followed by renourishment from periodic channel maintenance will have positive impacts on sea turtle nesting habitat, since the channel alignment and partial fill would provide some short-term and long-term shoreline stabilization to a portion of the North and Central Sections. According to Greene (2002), beach nourishment can benefit endangered and threatened sea turtles by restoring habitat along eroded beaches. Some studies have found no significant difference between nourished and non-nourished beaches in the number of eggs per nest, as well

as, hatching and emergence success (Nelson *et al*., 1985; Ryder, 1991). Other projects have shown increased numbers of nests, hatchlings, and survival rate of young turtles (Raymond, 1984).

Cumulative Effects. The realignment and maintenance of the New River Inlet channel and the nourishment of North Topsail Beach will help protect against long-term erosion resulting in the protection of the dry beach habitat. However, using only the material obtained from Inlet channel maintenance activities for periodic beach nourishment will not provide enough material for adequate storm protection along the entire 11.1 miles. Shoreline erosion and recession in the Permit Area will still occur, leading to negative cumulative effects on sea turtles and birds that utilize dry beach habitat.

5.3.3.3 WET BEACH COMMUNITIES

Alternatives 1 and 2: No Action and Buy-Out/Relocation

The impacts of Alternatives 1 and 2 on wet beach communities is expected to be essentially the same as described below.

Direct and Indirect Impacts. Wet beach communities in the Permit Area would persist in their current state under Alternatives 1 and 2. Without repositioning the New River Inlet entrance bar channel or nourishing the beaches with additional material, oceanfront shoreline erosion will continue reducing the width of the wet beach area. Sandbags used to provide storm protection for threatened structures, i.e., the northeast end of North Topsail Beach (see Section 1.3), can reduce the area of wet beach by providing a temporary barrier to the migration of wet beach along the active beach profile. According to the North Carolina Division of Coastal Management, 26 permits have been issued for sandbags since 1992 for oceanfront structures along North Topsail Beach. Sandbags are a temporary protection measure granted through permits issued by the NCDCM. New permits and permit extensions may be granted on a case by case basis. However expiration of the sandbag permits along the north end of North Topsail beach will expire when the Town is no longer actively pursuing a shoreline protection project. This would apply to Alternatives 1 and 2. Upon removal, the wet beach would return to natural conditions.

Cumulative Effects. Without realignment of the New River Inlet entrance channel and nourishment of beaches, the erosion of the North Topsail Beach and Onslow Beach shorelines is expected to continue, adding more sediment to the adjacent wet beach community. Alternatives 1 and 2 are not expected to have cumulative effects on the wet beach community.

Alternatives 3, 4, 5, and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of the New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and No Channel Maintenance, and Inlet Management Plan

Direct and Indirect Impacts. The addition of beach fill to North Topsail Beach will cause short-term direct impacts to the adjacent wet beach community. Beach fill material will equilibrate offshore where it will, at least temporarily, bury the wet beach community. As mentioned in Section 5.2, Nelson (1985) indicates that organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels. Although the wet beach infauna can adapt to fluctuations in the natural environment, the addition of sediment to the wet beach would have immediate, short-term negative impacts. Temporary burial of infaunal organisms could indirectly affect the birds and fish that forage on these organisms in the long-term. Impacts will be reduced due to the fact that the material utilized for beach fill will be compatible with native material, thereby reducing impacts to infaunal communities and sea turtle nesting. Furthermore, dredging will occur during the winter months while biological activity is reduced.

Cumulative Effects. Nourishment of the oceanfront shoreline of North Topsail Beach accompanied by realignment of the New River Inlet channel would initially add sediment to the wet beach community, however organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels (Nelson, 1985). Other studies reported by Maurer (National Research Council, 1995) supported the burial capabilities of nearshore species, which found that these species were capable of burrowing through sand up to 40 cm. Areas where fill will exceed 40 cm are expected to experience higher rates of infaunal mortality. These findings support a temporary decrease in population immediately after beach nourishment, followed by recovery of the wet beach infauna. However, this alternative includes supplemental nourishment from channel maintenance activities. As a result, negative cumulative effects could occur if the diversity and abundance of infaunal populations do not recover between nourishment events.

Impacts will be minimized to the wet beach due to the fact that no stretch of beach will generally receive renourishment within a four year time period, thereby allowing the infaunal resources to recover in between events. A study by Van Dolah *et al*. (1994) found the use of fill sediments that closely match the native sediments showed an ecological recovery of infaunal species within eight months. Thus, the use of borrow area sediment that are compatible with the native beach should prevent any negative long-term cumulative impacts to the nearshore softbottom communities. In addition, the recovery time of benthic infaunal species post-sand placement allows for new softbottom habitats to evolve as the shoreline builds seaward.

5.3.4 MARINE HABITATS

See Section 4.3.4 for description of marine habitats and the species that utilize the habitat.

5.3.4.1 NEARSHORE SOFTBOTTOM COMMUNITIES

Alternatives 1 and 2: No Action and Buy-Out/Relocation

Alternatives 1 and 2 would have the same results on nearshore softbottom communities as described below.

Direct and Indirect Impacts. Softbottom communities are dynamic in nature where periodic storms and seasonal climatic changes influence abundance and diversity of micro and macrofauna, tending toward a more opportunistic community (Mallin *et al*., 2000; Street *et al*., 2005). Softbottom communities may also change with natural shifting patterns of sediment erosion or deposition (Street *et al*., 2005). Alternatives 1 and 2 are not expected to have direct or indirect impacts, as the softbottom community's density and abundance may fluctuate over time, but overall would remain persistent and consistent.

Cumulative Impacts. The natural erosion of oceanfront shoreline along North Topsail Beach, over time, will move sediment into adjacent nearshore aquatic habitats. Natural changes in the softbottom habitat can affect the composition of micro and macrofauna present within the system. Alternatives 1 and 2 are not expected to provide additional impacts outside of natural processes.

Alternatives 3, 4, 5 and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of the New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Alternatives 3, 4, 5, and 6 would have similar impacts on nearshore softbottom with various timeframes as described below. Each alternative would be executed differently but each involves the placement of fill material from an offshore or upland borrow site and/or from the New River Inlet channel along 11.1 miles of shoreline (Alternatives 3, 4, and 5) or 7.25 miles of shoreline along North Topsail Beach (Alternative 6).

Direct and Indirect Impacts. Construction of the beach would result in the direct deposition of material from the dune or berm crest seaward to the construction toe-of-fill with an average contour depth of -1.3 m (-4.4 ft) NAVD in the North and Central Sections, and -1.2 m (-3.8 ft) NAVD in the South Section. Over time, the slope of the fill would adjust and equilibrate seaward to an average depth contour of -3.5 m (-11.6 ft) NAVD in the North and Central Sections, and -1.8 m (-5.9 ft)

NAVD in the South Section. Therefore, softbottom habitats located landward of these depths would be directly and indirectly impacted by project activities.

During construction and as the shoreline equilibrates, there is the potential for increased sediment deposition on this resource. However, minimization efforts have been designed for hardbottom communities that will also benefit nearshore softbottom communities in which placement of material along portions of the beach where hardbottom resources occur, include a perched beach design to avoid impacts to nearshore resources. The coarse material dredged from the New River Inlet channel and the offshore borrow area will be placed in the North and Central Sections in the vicinity of hardbottom outcroppings located approximately 350 m (1,150 ft) offshore of the February-March 2002 mean high water line (USACE baseline stations 855+00 to 890+00 and 1030+00 to 1075+00). Fill placement of the coarse material will extend beyond the limits of the shoreline that coincides with the hardbottom edge to account for possible longshore drift effects (between USACE baseline stations 840+00 to 900+00 and 1020+00 to 1160+00). This design measure is expected to result in the point-of-intercept (depth of closure) occurring approximately 244 m (800 ft) landward of the nearshore hardbottom edge.

Infaunal species have a dynamic species composition within these softbottom habitats and will experience short to intermediate-term impacts resulting from direct burial and associated localized elevated turbidity adjacent to the fill area. Short to intermediate-term impacts indirectly affect shorebird, crustacean and fish foraging along with impacting recreational fishing through a reduction in bait species.

Alternatives 3, 4, 5 and 6 all require periodic construction of the Central and North Sections, with the interim plan in the South Section to receive fill from both the borrow area and the New River Inlet channel. Periodic nourishment is expected to directly and indirectly affect softbottom communities by the continuation of sand placement over the long-term, except for Alternative 5 which does not include a long-term maintenance schedule. Alternative 3 includes a phased approach design which results in short-term, direct impacts, allowing for an earlier recovery period for softbottom communities since fill placement will generally occur every four years along individual stretches of the beach. The variable placement will allow for infaunal recruitment in a relatively shorter time frame than if fill occurred at one time along 11.1 miles. Maurer (National Research Council, 1995) supported the burial capabilities of nearshore species, which found that species in a softbottom community are capable of burrowing through sand up to 40 cm.

Alternatives 3, 5 and 6 include the dredging of the New River Inlet channel which involves direct, short term impacts to softbottom communities in the inlet. The original channel design included the addition of a connecting channel, extending the inlet bar channel up to Cedar Bush Cut. However, the connecting channel

was removed from the design in the early stages of project development due to the direct impacts to softbottom communities and potential indirect impacts to salt marsh, shellfish habitat and unknown submerged aquatic vegetative communities in the Inlet complex.

Softbottom communities will be directly impacted during construction; however the communities are not expected to be negatively affected over the long term.

Cumulative Impacts. The cumulative effect of past, present and future beach nourishment projects is a short- (Alternative 5) and long-term (Alternatives 3, 4, and 6), negative, direct impact resulting in the mortality of those infaunal species not adapted to avoidance of burial at the fill site and entrainment from the borrow area resulting from dredging operations. Research completed by Burlas *et al.* (2001) indicates that infaunal species populations recover within 2 to 6.5 months and sometimes up to two years after completion of nourishment projects. The recovery rate is influenced by temporal and spatial recruitment parameters such as distance to adjacent populations and season of project activity (Burlas *et al*., 2001).

An additional study by Van Dolah *et al*. (1994) found the use of fill sediments that closely match the native sediments showed an ecological recovery of infaunal species within eight months. Thus, the use of borrow area sediment that are compatible with the native beach should prevent any negative long-term cumulative impacts to the nearshore softbottom communities. In addition, the recovery time of benthic infaunal species post-sand placement allows for new softbottom habitats to evolve as the shoreline builds seaward. Impacts will be minimized due to the fact that no stretch of beach will receive renourishment within a four year time period, thereby allowing the infaunal resources to recover in between events.

Changes to the softbottom habitat can affect the composition of the micro and macrofauna present within the substrate. These changes may affect lower trophic organisms by reducing primary production and/or affecting higher trophic organisms (i.e. finfish) by reducing select food availability (Street *et al*., 2005). Softbottom communities are dynamic in nature, where periodic storms affect softbottom communities to depths of greater than 35 meters (Posey and Alphin, 2002). The diversity of micro and macrofauna tend to be dominated by opportunistic species that recover quickly when affected by natural causes (Mallin *et al.,* 2000; Street *et al*., 2005; Posey and Alphin, 2002). Active beach sand movements in North Carolina can occur in water depths from 0 to 40 feet. Softbottom communities may change with natural shifting patterns of sand erosion or deposition (Street *et al*., 2005). The continued periodic nourishment of the proposed project area, except with Alternative 5, may have negative cumulative impacts on the nearshore softbottom community food chain.

5.3.4.2 OFFSHORE SOFTBOTTOM COMMUNITIES

Alternatives 1 and 2: No Action and Buy-Out/Relocation

Alternatives 1 and 2 would have the same results on offshore softbottom communities as described below.

Direct and Indirect Impacts. Softbottom communities are dynamic in nature, where periodic storms affect softbottom communities to depths of greater than 35 meters (Posey and Alphin, 2002). The diversity of micro and macrofauna tend to be dominated by opportunistic species that recover quickly when affected by natural causes (Mallin *et al.,* 2000; Street *et al*., 2005; Posey and Alphin, 2002). Active beach sand movements in North Carolina can occur in water depths from 0 to 40 feet. Softbottom communities may change with natural shifting patterns of sand erosion or deposition (Street *et al*., 2005). Under Alternatives 1 and 2, the offshore softbottom community's density and abundance may fluctuate over time but would remain persistent and consistent overall. Outside of existing natural processes no impacts are anticipated with Alternatives 1 and 2.

Cumulative Impacts. Natural changes in the softbottom habitat can affect the composition of the micro and macrofauna present within the system; however, there is a lack of research identifying the cumulative effects of softbottom communities from natural events. These changes may affect lower trophic organisms by reducing primary production and/or affect higher trophic organisms (i.e. finfish) by reducing select food availability (Street *et al*., 2005). No cumulative impacts are expected to occur outside of natural processes.

Alternatives 3, 4, 5 and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of the New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and No Channel Maintenance, and Inlet Management Plan

Preferred Alternative 3 and Alternatives 4, 5, and 6 would have similar impacts on offshore softbottom as described below. In the event that an upland borrow source rather than an offshore borrow source is identified for Alternative 4, offshore softbottom communities will be minimally affected. However, if an offshore borrow area is developed with Alternative 4, impacts will be similar to Alternatives 3, 5, and 6. The alternatives would be executed differently but each involves the periodic dredging of fill material from an offshore borrow area.

Direct and Indirect Impacts. Dredging from an offshore borrow area results in a direct, short-term mortality of all organisms present within the dredged material (Posey and Alphin, 2002). Although the recruitment pattern is altered, the recovery of species after sediment removal is relatively quick, depending upon the opportunistic nature of the species (Street *et al*., 2005; Posey and Alphin, 2002). At dredge sites monitored off the coast of New Jersey, infaunal

assemblages recovered within one year after disturbance, while biomass and taxonomic richness took 1.5 to 2.5 years to recover (Street *et al*., 2005; USACE, 2001).

Periodic storms affect softbottom communities to depths of greater than 35 meters (Posey and Alphin, 2002). The diversity of micro and macrofauna tend to be dominated by opportunistic species that recover quickly when affected by natural causes (Mallin *et al*., 2000; Street *et al*., 2005; Posey and Alphin, 2002). Softbottom communities may also change with natural shifting patterns of sediment erosion or deposition (Street *et al*., 2005). Posey and Alphin (2002) suggests that effects of beach nourishment from dredging of an offshore borrow area is minimal compared to the natural variability of the system.

Cumulative Impacts. Periodic use of the offshore borrow area for maintaining the South, Central, and North Sections is expected to impact the softbottom habitat in the borrow area through phase five of the project which could result in potential long-term direct impacts if the dredge site does not fill in. The time in between the periodic maintenance associated with Alternatives 3, 4, and 6 will allow for recovery of the habitat. Based on geotechnical investigations (Appendix C), initial borrow area depths range from -10.2 to -11.8 m (-33.5 to -39.0 ft) below mean sea level, whereas sediment thickness or depth cuts within the borrow area ranges from -12.1 to -16.3 m (-40.0 to -53.5 ft) below mean sea level. Impacts will be reduced due the utilization of a cutterhead dredge. These dredges are known to cause reduced turbidity in comparison to hopper dredges.

Changes in the softbottom habitat can affect the composition of the micro and macrofauna present within the system. The softbottom community provides foraging habitat for herbivores and predaceous fish. Softbottom habitat supports hardbottom fish communities and is linked to hardbottom fish production as well. Changes in the system may affect lower trophic organisms by reducing primary production and/or affect higher trophic organisms by reducing select food availability (Street *et al*., 2005). The offshore softbottom community food chain may be affected by long-term cumulative effects from dredging operations, natural seasonal variations and storm events.

Alternative 3 involves utilizing material obtained from both New River Inlet and offshore borrow areas for the initial nourishment. The footprint of the offshore borrow areas to be dredged will encompass a total of 166 acres (based off the needed volume of 2,296,400 at cut depths of 8.4 feet and 9.7 feet from the two sites). Subsequent nourishment events associated with Alternative 3 will be limited to material from the New River Inlet, therefore offshore softbottom areas will not be additionally impacted after construction of all 5 phases. Alternatives 4 and 5 will impact 315 and 199 acres of offshore borrow areas, respectively, based off the necessary fill volumes of 4,301,600 for Alternative 4 and 2,730,200 for Alternative 5. Phases 2-5 will also utilize offshore borrow areas for

Alternatives 4 and 5. Alternative 4 will disturb an additional 301 acres for phases 2-5 while Alternative 5 will disturb an additional 317 acres for phases 2-5.

5.3.4.3 HARDBOTTOM COMMUNITIES

See Section 4.3.4.2 for description of hardbottom habitats and the species that utilize the habitat.

5.3.4.3.1 Nearshore Hardbottom

Alternatives 1 and 2: No Action and Buy-Out/Relocation

Alternatives 1 and 2 would have similar impacts on nearshore hardbottom communities as described below.

Direct and Indirect Impacts. Nearshore hardbottom communities will likely remain unchanged and will continue to be affected only by current natural conditions. Existing known natural conditions range from short-term and long-term covering and uncovering of hardbottom resources as a result of natural sand movement from longshore drift effects, persistent high wave energy and storm surge. Outside of existing natural processes no impacts are anticipated with Alternatives 1 and 2.

Cumulative Impacts. Natural long-shore transport of sediments may indirectly affect nearshore hardbottom by temporarily covering hardbottom resources due to existing natural conditions and/or seasonal variations. It is likely that natural shifts in the ephemeral community structure or use of habitat will occur with implementation of Alternatives 1 and 2.

Alternatives 3 and 6: Inlet Management Plan with Beach Nourishment and Inlet Management Plan

Preferred Alternative 3 and Alternative 6 would have similar effects on nearshore hardbottom communities as described below.

Direct and Indirect Impacts. During the project planning and design phase, the beach fill design was revised to avoid impacts to nearshore hardbottom resources. The revised design includes selective dredging and select placement of fill material to create a perched beach design along specific areas of the beach. This design initiative helps avoid direct and potentially indirect impacts to nearshore hardbottom resources. The offshore borrow area was designed to identify specific areas of coarse material to be used for the perched beach fill design. The coarse material dredged from New River Inlet and the offshore borrow area will be placed in the North and Central Sections in the vicinity of hardbottom outcroppings located approximately 350 m (1,150 ft) offshore of the February-March 2002 mean high water line (USACE baseline stations 855+00 to

890+00 and 1030+00 to 1075+00). Fill placement of the coarse material will extend beyond the limits of the shoreline that coincides with the hardbottom edge to account for possible longshore drift effects (between USACE baseline stations 840+00 to 900+00 and 1020+00 to 1160+00). This design measure is expected to result in the point-of-intercept (depth of closure) occurring approximately 244 m (800 ft) landward of the nearshore hardbottom edge. As a result of the above described minimization and avoidance measures, along with the implementation of a monitoring plan, long-term direct or indirect impacts to nearshore hardbottom are not expected with Alternatives 3 and 6. Additional avoidance and minimization measures which helps to reduce or avoid direct and indirect impacts are discussed in detail in Section 6.

Cumulative Impacts. Over a 30 year period, periodic nourishment of the North and Central Sections and the interim plan for the South Section would continue to use the inlet as a source of fill material. The material to be obtained from the inlet is similar coarse material that would be used in areas where nearshore hardbottom is in close proximity to the point of intercept with fill material. With these alternatives, natural long-shore transport of sediments may indirectly affect nearshore hardbottom by temporarily covering hardbottom resources due to existing natural conditions and/or seasonal variations. Similar to Alternatives 1 and 2, it is likely that natural shifts in the ephemeral community structure will occur regardless of the implementation of Alternatives 3 and 6.

Alternative 4: Beach Nourishment without the Relocation of the New River Inlet Bar Channel

Direct and Indirect Impacts. Alternative 4 would utilize the offshore and/or upland borrow areas for fill material for the nourishment of the North and Central sections, and the interim plan for the South section. Due to the limited amount of coarse grained sediment in the offshore borrow area; avoidance of nearshore hardbottom resources would not be possible without a reduction in the fill design width. Otherwise a new source of compatible material would need to be identified from either an offshore sand source or upland borrow site. The compatibility of material from an upland borrow site is unknown.

Cumulative Impacts. A depletion of the offshore borrow area may result in exclusion of some sections for nourishment. The existing coarse material would be depleted under Alternative 4 and a new source of coarse material would need to be identified. Like Alternative 3, nearshore hardbottom impacts could be avoided by successfully identifying other sources of compatible coarse grained material. Periodic nourishment of the project area would have to be accomplished entirely from the use of a new offshore or upland borrow area.

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas

Direct and Indirect Impacts. Like Alternative 3, placement of material along portions of the beach where hardbottom resources occur, include a perched beach design method in areas to avoid impacts to nearshore hardbottom resources. The coarse material dredged from New River Inlet and the offshore borrow area will be placed in the North and Central sections in the vicinity of hardbottom outcroppings located approximately 350 m (1,150 ft) offshore of the February-March 2002 mean high water line (USACE baseline stations 855+00 to 890+00 and 1030+00 to 1075+00). Fill placement of the coarse material will extend beyond the limits of the shoreline that coincides with the hardbottom edge to account for possible longshore drift effects (between USACE baseline stations 840+00 to 900+00 and 1020+00 to 1160+00). This design measure is expected to result in the point-of-intercept (depth of closure) occurring approximately 244 m (800 ft) landward of the nearshore hardbottom edge. As a result of the above described minimization and avoidance measures, long-term direct or indirect impacts to nearshore hardbottom are not expected with Alternative 5. Additional minimization and avoidance measures are described in detail in Section 6.

Cumulative Impacts. The coarser grained material from the Inlet and offshore borrow area could be reduced after the first nourishment event. Without using coarse grained material on beach segments near hardbottom, the nearshore hardbottom could be buried and negatively impacted, as expected with Alternative 4 as well. This could also indirectly negatively impact turtle resting and foraging areas and the ephemeral hardbottom community species. However, Alternative 5 is a one-time event therefore no negative cumulative impacts are expected.

5.3.4.3.2 Offshore Hardbottom

Alternatives 1, 2 and 6: No Action, Buy-Out/Relocation, and Inlet Management Plan

Alternatives 1, 2 and 6 would have similar results on the offshore hardbottom communities as described below.

Direct and Indirect Impacts. Approximately 1,652,857 sq mi of offshore hardbottom habitat has been identified in the Permit Area. This resource is generally less ephemeral than the nearshore hardbottom resource; normally supporting greater diversity and density of associated species. Although this resource is outside the active sand sharing system, it is susceptible to sedimentation from more highly transportable silts and clays. In general the resource presents a more stable environment than nearshore hardbottom; however, the resource is affected by natural processes such as hurricanes and floods.

CPE marine biologists confirmed offshore hardbottom at two locations in June 2005 which were covered by > 60 cm (2 ft) of mud in October 2005 (CPE, 2006) following direct impact from Hurricane Ophelia (11-14 September) (NOAA, 2006) and peripheral effects associated with other hurricanes during that season.

Offshore hardbottom communities would likely remain unchanged under Alternatives 1, 2, and 6.

Cumulative Impacts. No cumulative impacts would occur to offshore hardbottom resources under Alternatives 1, 2 and 6 other than existing natural processes such as extreme storm events.

Alternatives 3, 4 and 5: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of the New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and No Channel Maintenance

Alternative 3 and Alternatives 4 and 5 would have similar effects on offshore hardbottom communities as described below. The alternatives would be executed differently but each involves the periodic dredging of fill material from an offshore borrow area, except for Alternative 5.

Direct and Indirect Impacts. Alternative 3 and Alternative 4 involve dredging the offshore borrow area to extract fill material for nourishment of the North Topsail Beach oceanfront shoreline. The use of a cutterhead suction dredge will minimize turbidity during dredging activities and will limit the impact of sedimentation to hardbottom resources located near the borrow area.

In addition, the inclusion of a 400-foot buffer zone around the hardbottoms will be enforced during dredging activities. This additional precaution has been successfully executed in Atlantic and Gulf coast beach nourishment projects. A hardbottom monitoring plan was developed to detect physical and/or biological changes of the hardbottom resources. The plan includes monitoring of these resources pre-, mid- and post-construction. Also included in the plan are several minimization and avoidance measures for occurring near hardbottom resources (see Section 6 for details). As a result of these avoidance measures, no impacts to the offshore hardbottom resources are anticipated under Alternatives 3, 4, and 5. The dredging activity within the borrow area is not expected to have an effect on this resource.

Cumulative Impacts. Diver observations, before and after Hurricane Ophelia in September 2005, indicate that this resource is significantly influenced by storm activity and flood flow emanating from the New River catchment. The magnitude and significance of environmental consequences associated with the proposed project, combined with the temporal and spatial separation of similar projects are considered to be negligible. Impacts to offshore hardbottoms are expected to be

minimized due to the implementation of the hardbottom monitoring program as described in Section 6. Therefore, no cumulative impacts are expected to occur under Alternatives 3, 4 and 5.

5.4 WATER QUALITY

Water quality includes an assessment of potential changes in turbidity and salinity levels in subtidal environments within the Permit Area.

5.4.1 Turbidity

Alternatives 1 and 2: No Action and Buy-Out/Relocation

The impacts of Alternatives 1 and 2 on turbidity levels would be essentially the same as described below.

Direct and Indirect Impacts. Excessive sediment loading increases turbidity and sedimentation, which can result in a decrease in biological productivity, clogging of fish gills, and reduced recruitment of invertebrates. Furthermore, turbidity can suppress SAV growth, cause low oxygen events leading to fish kills, and cause mortality of organisms in the bottom community, including oysters. Natural conditions within the Permit Area support extreme fluctuations in turbidity levels as a result of 1) the winnowing away of exposed peat and mud layers near the oceanfront shorelines of North Topsail Beach and Onslow Beach, and 2) the discharge of organics and fine sediments from the New River. Under Alternatives 1 and 2, natural erosive processes of the oceanfront shoreline would continue with minimal changes in turbidity levels as a result.

Cumulative Effects. Natural conditions support fluctuating turbidity levels (9.7 to 35.2 Nephelometric Turbidity Units) in the nearshore and offshore water column of the Permit Area. These natural fluctuating turbidity levels would continue under Alternatives 1 and 2.

Alternatives 3, 4, 5, and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of the New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and No Channel Maintenance, and Inlet Management Plan

Direct and Indirect Impacts. Excavation of the new channel and/or offshore borrow area is expected to result in temporary increases in suspended sediment and turbidity in the immediate area of construction activity. While there is no direct correlation between suspended sediment and turbidity, the low suspended sediment concentration combined with the low silt content of the Inlet and offshore borrow material resulted in the conclusion that turbidity should remain within the State Standards. Any increase in turbidity associated with the

excavation of the channel or offshore borrow area to the oceanfront shoreline should be of short duration.

Cumulative Effects. Natural conditions support fluctuating turbidity levels (9.7 to 35.2 Nephelometric Turbidity Units) in the nearshore and offshore water column of the Permit Area. These fluctuating turbidity levels would continue with or without the beach nourishment and dredging efforts proposed under Alternative 3. Therefore, no cumulative effects are expected to occur from the dredging and placement activities.

5.4.2 SALINITY

Alternatives 1, 2, and 4: No Action, Buy-Out/Relocation, and Beach Nourishment without the Relocation of the New River Inlet Bar Channel

Direct and Indirect Impacts. Alternatives 1, 2 and 4 are not expected to change salinity levels in the area since this activity does not change the hydrodynamics of the Inlet.

Cumulative Effects. No cumulative effects on salinity are expected to result from Alternatives 1, 2, and 4.

Alternatives 3, 5, and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Direct and Indirect Impacts. During an average year, New River Inlet has natural fluctuations in salinity ranging from high, transitional, to low depending on tide conditions and antecedent rainfall/runoff conditions. The dimensions of the new channel were selected based on the ability of the new channel to capture the majority of the tidal flow through New River Inlet. As stated in Appendix B (Engineering Analysis), the cross-sectional area of the inlet is expected to adjust to accommodate the fluctuating tidal prisms within a several months. As tidal exchange will not be modified, salinity levels in the Inlet environment will be maintained at existing levels. Therefore, no permanent changes in salinity above natural fluctuations are expected to occur from the channel relocation without beach nourishment alternative.

Cumulative Effects. Due to the minimal changes in tidal prism, salinity levels are not anticipated to change as a result of these alternatives and therefore, no cumulative impacts are expected to occur (see Appendix B- Engineering Analysis).

5.5 AIR QUALITY

None of the alternatives are expected to impact on air quality.

5.6 PUBLIC SAFETY

Alternatives 1 and 2: No Action and Buy-Out/Relocation

Direct and Indirect Impacts. Erosion of the northeastern end of North Topsail Beach would continue to threaten and eventually destroy the homes on the north end. In response to the threat, property owners would begin to take measures to demolish the threaten buildings and transport the construction debris to sanitary landfills. The activity associated with the demolition could expose workers to risk of injury comparable to similar construction activities. There is also a strong possibility that some debris could fall into the nearshore which could pose health threats to people swimming or boaters. As the erosion undermines existing roads and sanitary systems, exposes electrical lines, and ruptures or requires the relocation and rerouting of the water supply system, the public would be exposed to increased risk of injury and/or infection. The six duplex residential structures demolished in mid-February, 2009 were initially deemed inhabitable in April 2006 (Woodle, pers. comm.). The nearly 3 year delay between condemnation and demolition added to public safety concerns.

Cumulative Effects. Demolition activities, road undermining, and exposure of utilities would continue as long as the inlet shoreline migrates to the east. The longer the situation exists, the higher the risk of personal injury due to the abandonment and eventual demolition of homes and infrastructure on North Topsail Beach over the next 30 years. Raw sewage leaking from exposed septic tanks and the rupture or relocation of the water supply system would increase the risk of disease and infection.

Alternatives 3, 4, 5 and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of the New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Direct and Indirect Impacts. All of the safety and public health safety risks associated with the continued erosion of the northeast end of North Topsail Beach, as described under Alternatives 1 and 2, should eventually be eliminated. Long term accretion along the northeast end of North Topsail Beach should occur within five years, with beach and ebb shoal equilibration occurring within 15 years following the inlet relocation. Safety and public health concerns (as described under Alternatives 1 and 2) will continue until the equilibrium will be reached, thereby reducing the risk. During construction, safety and public health concerns will be minimized due to the utilization of a lit dredge and buoys

indicating the location of submerged anchors. Furthermore, the disposal area along the beach will be roped off to keep the public at a safe distance from the effluent.

Cumulative Effects. The general welfare of the property owners at the north end and visitors to the inlet shoreline should greatly improve over existing conditions as the shoreline adjusts and builds up. Alternative 5 will provide short term protection, however, long-term shoreline protection under Alternatives 4 and 5 are not anticipated under these two alternatives. Without fixing the configuration of the New River Inlet to the preferred location, erosion will continue along the northern shoreline of North Topsail Beach.

5.7 AESTHETIC RESOURCES

Alternatives 1, 2, and 4: No Action, Buy-Out/Relocation, and Beach Nourishment without the Relocation of New River Inlet Bar Channel,

The impacts of Alternatives 1, 2, and 4 are expected to be essentially the same as described below.

Direct and Indirect Impacts. Alternatives 1, 2, and 4 would lead to the continued erosion of the northeast end of North Topsail Beach and threatened homes and roads would be abandoned and demolished or relocated to other areas within the Town limits. The presence of abandoned homes left along the shoreline will most likely persist for a period of time prior to subsequent demolition as was the case with six duplexes in 2006. These homes were initially condemned in April of 2006, yet were not razed until March 2009 (Woodle, pers. comm.). During those times when demolition or relocation activities are underway, the presence of construction equipment would temporarily detract from the aesthetics of the Town.

Cumulative Effects. Continued loss of land could lead to the loss of multiple residences and infrastructure. Continued erosion along the Town's oceanfront shoreline could also result in a significant loss of land, personal property, and roads, which would negatively affect the quality of North Topsail Beach.

Alternatives 3, 5 and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Direct and Indirect Impacts. The use of the Inlet channel and offshore borrow material to nourish the oceanfront shoreline would create a wider recreational beach with qualities essentially the same as the existing beach. Similar to 1 and 2, Alternatives 3, 5 and 6 would restore the aesthetic qualities of a stable oceanfront shoreline in the short-term.

Cumulative Effects. Positive cumulative effects would be assumed from continued maintenance of the oceanfront shoreline. While these alternatives will benefit the majority of beach, Alternative 5 provides negative aesthetic impacts because without maintaining the realigned inlet, long term erosion will allow for the continuance of exposed infrastructure and abandonment of homes.

5.8 RECREATIONAL RESOURCES

Alternatives 1 and 2: No Action and Buy-Out/Relocation

Direct and Indirect Impacts. The continued erosion of the Inlet shoreline would make it difficult to reestablish public access to the Inlet shoreline to the same degree that existed in the past. Access from the ocean shoreline to the inlet would require negotiating a rather narrow beach in front of a vertical erosion scarp. The direct and indirect negative effects to the recreational beach would continue in the short-term due to condemned homes, sandbags, and reduced beach width along the inlet shoreline. Furthermore, the narrow beach will limit the space used for typical beach activities including fishing, sunbathing, and general recreation.

Cumulative Effects. The continued erosion of the inlet shoreline would make it difficult to reestablish public access to the inlet shoreline to the same degree that existed in the past. Due to the erosion and narrowing of the oceanfront shoreline, access from the ocean shoreline to the inlet would require negotiating a rather narrow beach in front of a vertical erosion scarp. Without incorporating beach nourishment or Inlet management, the direct and indirect negative effects from the loss of the beach would continue in the long-term.

Alternatives 3, 4, 5 and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Direct and Indirect Impacts. The use of the Inlet channel and offshore borrow material to nourish the oceanfront shoreline would create a wider recreational beach with qualities essentially the same as the existing beach leading to positive direct impacts.

Cumulative Effects. The high quality beach fill along the oceanfront shoreline of North Topsail Beach would have a positive impact on visitors and would encourage their return in later years. Access to the Inlet would also provide greater recreational opportunities than presently exists which should also enhance future and repeat visitations.

5.9 NAVIGATION

Alternatives 1, 2 and 4: No Action, Buy-Out/Relocation, Beach Nourishment without the Relocation of New River Inlet Bar Channel

Direct and Indirect Impacts. Alternatives 1, 2, and 4 would not have any impact on existing navigation conditions in New River Inlet.

Cumulative Effects. Controlling depths in New River Inlet will continue to be shallower than the authorized depth of 2.4 m (8 ft) below MLW and the channel will continue to shift locations making it unreliable for commercial fishing interests operating out of Sneads Ferry and other nearby ports. The U.S. Coast Guard has noted that while New River Inlet continues to be navigable for recreational boaters, shoaling occurs regularly requiring continuous monitoring and relocation of navigational buoys (Lyon, pers. comm.). The variability of the channel depth and location will also have a continuing negative effect on the recreational use of the inlet.

Alternatives 3 and 6: Inlet Management Plan with Beach Nourishment, Inlet Management Plan

Direct and Indirect Impacts. The dimensions of the centrally located channel, which would have a depth of -5.5 m (-18 ft) NAVD and a maximum width of 152 m (500 ft) across a large portion of the ebb tide delta, would greatly exceed the authorized dimensions of the navigation channel. Although this project is not for navigational purposes, the new channel would provide a relatively deep channel for some period of time following its construction.

Cumulative Effects. Continued management of the Inlet would provide positive cumulative effects for navigation through the Inlet.

Compatibility with Project Objectives. Alternatives 3 and 6 will meet the navigation needs of the recreational and commercial (shrimp) boats that utilize New River Inlet.

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas

Direct and Indirect Impacts. The dimensions of the centrally located channel, which would have a depth of -5.5 m (-18 ft) NAVD and a maximum width of 152 m (500 ft) across a large portion of the ebb tide delta, would greatly exceed the authorized dimensions of the navigation channel. Although this project is not for navigational purposes, the new channel would provide a relatively deep channel for some period of time following its construction. However, even this positive impact is expected to be relatively short lived as estimates of shoaling of the new channel for the case in which the existing channel is artificially filled indicates that

controlling depths should again approach -2.4 m (-8 ft) MLW in approximately one year after construction.

Cumulative Effects. Recovery along the north end would occur over the first 5 years following channel relocation and then the channel is expected to migrate back to its current position 11 years after relocation. Therefore, the current inlet conditions is expected to persist in the long term resulting back to pre-construction conditions as stated in Alternatives 1 and 2 above.

5.10 INFRASTRUCTURE

Alternatives 1 and 2: No Action and Buy-Out/Relocation

The impacts of Alternatives 1 and 2 would be essentially the same as described below.

Direct and Indirect Impacts. The thirty-eight 1,000-foot reaches along the project area contain 1,158 housing units. Housing units include single family homes as well as multi-family structures such as the St. Moritz (Reach 82), Villa Capriani (Reach 97), Topsail Villas (Reach 98), Topsail Dunes (Reach 110), Ship Watch Villas (Reach 111), St. Regis Resort (Reach 112), and Topsail Reefs (Reaches 114-115). The North Topsail Beach tax database lists approximately 500 housing units as rental properties. The continued erosion of the oceanfront shoreline could result in the destruction of many of the homes, roads, and service utilities within this area. Engineering analysis suggests that within five years, a total of 50 structures comprised of 224 residential condominium units could be lost due to erosion. Within 6 to 10 years from now, an additional 19 structures with 77 residential units would also be lost (see Appendix B- Engineering Analysis for time series of structural loss as it relates to tax revenue). If threatened structures are not moved, they would have to be demolished with the debris deposited in local sanitary landfills. The same would apply to damage to the subdivision roads and some service utilities.

Cumulative Effects. Without the abatement of the shoreline erosion, engineering analysis suggests that over a 30 year period a total of 253 structures comprised of 485 residential units will be destroyed. Along with this, it is estimated that 9,000 feet of road and associated utilities (power and water) would be lost by year 20 in Reaches 101 to 109. Day to day driving would be compromised as would storm evacuation routes. This will result in significant negative cumulative effects to infrastructure on North Topsail Beach.

The cumulative effect of demolition and removal of homes and infrastructure debris could reduce the amount of space available at the local landfill over the next ten years. The volume of material that may have to be placed in the landfill is not likely to be considered significant, but ultimately this additional material

may have to be accounted for in the County's long range plan for solid waste facilities.

Alternatives 3, 4, 5 and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Direct and Indirect Impacts. Alternatives 3, 4, 5 and 6 would have positive direct and indirect impacts on infrastructure as these resources would be given protection from chronic and storm related erosion. The number of structures which would have otherwise been destroyed under Alternatives 1 and 2 would be spared. Similarly, the roadside utility infrastructure (power and water) would also be positively impacted through the implementation of Alternatives 3, 4, 5, and 6. This would also benefit day to day driving and transportation needs as well as storm evacuation routes. Therefore, positive direct and indirect impacts would be achieved. However, infrastructure would remain threatened during the interim period of 5 years as equilibrium is reached.

Cumulative Effects. Alternatives 3, 4, 5 and 6 would have positive cumulative impacts on infrastructure as these resources would be given protection from chronic and storm related erosion. The 253 structures and associated 485 residential units would not be destroyed over the 30 year period, nor would the 9,000 feet of roadway and associated utilities. This would also positively impact day to day driving and transportation needs as well as storm evacuation routes. Therefore, positive cumulative impacts would be achieved.

5.11 URBAN QUALITY

Alternatives 1 and 2: No Action and Buy-Out/Relocation

The impacts of Alternatives 1 and 2 would be essentially the same as described below.

Direct and Indirect Impacts. Alternatives 1 and 2 would lead to the continued erosion of the north end of North Topsail Beach and threatened homes and roads would be abandoned and demolished or relocated to other areas within the Town limits. During those times when demolition or relocation activities are underway, the presence of construction equipment would temporarily detract from the aesthetics of the Town.

Cumulative Effects. Continued loss of land could lead to the destruction of multiple residences and infrastructure. Continued erosion along the Town's oceanfront shoreline could also result in a significant loss of land, property, and roads, which would negatively affect the urban quality of North Topsail Beach.

Alternatives 3, 4, 5 and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Direct and Indirect Impacts. Alternatives 3, 4, 5 and 6 would provide positive direct or indirect impacts on urban quality by restoring the oceanfront shoreline in the short-term.

Cumulative Effects. Over the long-term, Alternatives 3, 4, 5 and 6 would support positive cumulative effects to North Topsail Beach.

5.12 SOLID WASTE

Alternatives 1, 2, and 4: No Action, Buy-Out/Relocation, and Beach Nourishment without the Relocation of New River Inlet Bar Channel

The impacts of Alternatives 1, 2 and 4 are anticipated to essentially be the same as described below. Hazardous solid waste is discussed in Section 5.15.1.

Direct and Indirect Impacts. The continued erosion of the oceanfront shoreline could result in the destruction of homes, roads, and service utilities. If threatened structures are not moved, they would have to be demolished with the debris deposited in local sanitary landfills. The same would apply to damage to the subdivision roads and some service utilities. The homes located on North Topsail Beach are fitted with septic systems which will add to the negative impacts of solid waste if this sewage enters the water or becomes exposed to the environment.

Cumulative Effects. The cumulative effect of demolition and removal of homes and infrastructure debris could reduce the amount of space available at the local landfill over the next ten years. The volume of material that may have to be placed in the landfill is not likely to be considered significant, but ultimately this additional material may have to be accounted for in the County's long range plan for solid waste facilities.

Alternatives 3, 5, and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Direct and Indirect Impacts. Alternatives 3, 5, and 6 would directly and indirectly effect solid waste during the period of time between the realignment of the inlet and when shoreline erosion is abated. Accretion along the northeast end of

North Topsail Beach should occur within five years, with beach and ebb shoal equilibration occurring within 15 years following the Inlet relocation.

Cumulative Effects. Abating the erosion along the northern portion of North Topsail Beach will provide protection to homes and infrastructure. Therefore the implementation of Alternatives 3 and 6 will provide positive impacts to solid waste. Alternative 5 will also provide positive impacts to solid waste; however, due to the fact that the inlet will not be maintained in the preferred alignment under this alternative, the long-term impacts may be negative.

5.13 DRINKING WATER

Alternatives 1 and 2: No Action and Buy-Out/Relocation

The impacts of Alternatives 1 and 2 would be essentially the same as described below.

Direct and Indirect Impacts. Erosion of the Inlet shoreline over the next 10 years could affect the potable water distribution system that serves the north end of North Topsail Beach. Once a section of the service line is threatened, the Town would have to disconnect that section of the line and reroute it to serve remaining properties. Disconnecting and rerouting the potable water service system would necessitate implementation of a boil water directive for all affected residents for some period of time following resumption of service.

Cumulative Effects. Impacts on drinking water would be continuous and cumulative as long as the inlet shoreline continues to migrate to the east.

Alternatives 3, 4, 5 and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Direct and Indirect Impacts. Positive direct and indirect impacts to drinking water supplies or facilities are expected to result from Alternatives 3, 4, 5 and 6 due to the protection of the Town's infrastructure.

Cumulative Effects. Positive cumulative impacts are anticipated due to the protection of the Town's infrastructure.

5.14 Hazardous, Toxic, and Radioactive Waste.

Alternatives 1 and 2: No Action and Buy-Out/Relocation

The impacts of Alternatives 1 and 2 are expected to be essentially the same as described below.

Direct, Indirect, and Cumulative Impacts. Hazardous waste may become problematic should the anticipated shoreline erosion cause the destruction of structures and infrastructure. Engineering analysis suggests that within five years, a total of 50 structures comprised of 224 residential units could be lost due to erosion. Within 6 to 10 years from now, an additional 19 structures with 77 residential units would also be lost. It is estimated that 253 structures and associated 485 residential units would be destroyed over the 30 year period, as would 9,000 feet of roadway and associated utilities. Of the 12 residential units demolished in March 2009 on North Topsail Beach, 6 were certified to contain asbestos (Woodle, pers. comm.). Lead was also assessed, however no units were found to be contaminated. These homes also contained septic tanks. If these tanks were not abandoned properly, waste containing pathogens could be introduced to the environment where human contact could occur. Utilities containing hazardous materials, including telephone wires, could also be introduced to the environment causing additional direct, indirect, and cumulative impacts.

Alternatives 3, 4, 5 and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Direct, Indirect, and Cumulative Impacts. There is a potential for hydrocarbon spills with dredging and construction equipment in the areas, but accident and spill prevention plans delineated in the contract plans and specifications should prevent most spills.

Benefits are expected with the removal of hazardous waste as a result of Alternatives 3, 4, 5 and 6 due to the protection of the Town's structures and infrastructure. The hazardous waste materials potentially associated with these structures and infrastructure would not be released into the environment, therefore they are not expected to present negative impacts to humans or the environment.

5.15 ECONOMICS

Alternatives 1: No Action

Direct and Indirect Impacts. Impacts from Alternative 1 occur over the long-term. Direct and indirect impacts are not considered.

Cumulative Effects. The continuation of this erosion response alternative over the next 30 years would result in significant economic loss to the Town, County, and State in the form of reduced revenues from ad valorem, room occupancy, and sales taxes. Individual property owners would also experience substantial economic losses associated with the cost of either moving or abandoning their threaten buildings. Continuation of the past erosion trends would also necessitate the relocation of an 2,438 m (8,000 ft) section of New River Inlet Road, located along the northern reaches of the Town, in approximately 20 years. Relocation of this section of the road could be required sooner should the area be impacted by a moderate to severe coastal storm in the next 10 years. With regard to storm damages, the existing condition of the beach puts a large number of oceanfront structures at a high risk for damage and possibly total destruction.

The greatest negative impacts of the No Action Alternative on the local economy would be realized from damages caused by a continuation of past shoreline erosion and the impacts of coastal storms ($23.2 million/year, a loss of rental property and the associated reduction in rental income ($4.2 million/year), and a reduction in local spending by vacationers and permanent residents displaced as a result of the loss of their primary residence ($5.6 million/year). The average annual economic impact of these losses over the 30-year evaluation period totals $33.3 million/year for the Central and North Sections.

The loss of structures over the 30-year analysis period would result in a $366,100/year reduction in ad valorem tax revenues for the Town and County. Room accommodation tax revenues would also be reduced by an average of $254,600/year while sales tax revenues would be reduced by $395,200/year.

Alternative 2: Buy-Out/Relocation

Direct and Indirect Impacts. The Buy-Out Alternative is similar to the No Action Alternative except temporary sand bag revetments would not be used to protect threatened structures.

Cumulative Effects. Once a structure becomes threatened by long-term erosion, the structure would be moved to a new lot, moved back on its existing lot, or demolished. The number of structures that would be impacted under the Buy-Out Alternative would be the same as with the No Action Alternative. The major differences between the No Action Alternative and the Buy-Out Alternative would be the elimination of sand bag costs and the time when some action regarding

the threatened structures would have to be taken. In this regard, the sand bag revetments were assumed to prolong the life of structures with less than 5,000 sq ft of floor space by two years and five years for structures with a floor space greater than 5,000 sq ft. Accordingly, under the Buy-Out Alternative relocation and/or demolition of threatened structures would occur two to five years earlier than under the No Action Alternative.

As was the case for the No Action Alternative, the section of New River Inlet Road located between baseline stations 1010+00 and 1080+00 (Reaches 101 and 108) would be protected with sand bag revetments until year 20 at which time the road would be relocated. Failure to maintain this section of New River Inlet Road would result in the cutoff of land access to the northern portions of the Town which would essentially result in the complete abandonment of everything north of baseline station 1070+00 (Reach 107) in year 10 and everything from baseline stations 1010+00 to 1060+00 (Reach 101 to 106) in year 15.

Alternative 3: Inlet Management Plan with Beach Nourishment

Direct and Indirect Impacts. The Inlet Management Plan with Beach Nourishment Alternative would protect the tax base in the Central and North Sections of North Topsail Beach against losses due to a continuation of long-term erosion. In so doing, the estimated losses under the No Action Alternative for income from vacation rentals and local spending and the occupancy taxes and sales taxes derived from these activities would be prevented. Potential tax revenue saved includes a total of $366,100 per year in Town and County ad valorem taxes, $254,600 per year in room occupancy taxes, and $395,200 in State and local sales taxes.

Cumulative Effects. Alternative 3 would involve utilizing material from the offshore borrow areas and/or material from New River Inlet. An evaluation of the costs for using upland borrow sources to construct and/or maintain Alternative 3 is also provided in the Cost Estimates section of Appendix B – Engineering Analysis.

Alternative 4: Beach Nourishment without the Relocation of New River Inlet Bar Channel

Direct and Indirect Impacts. The potential reduction in storm and erosion damages for the 14-foot (NAVD) dune plan could reduce potential storm and erosion damages between baseline stations 785+00 and 1135+00 (Reaches 79 to 113) by $13.62 million/year which is the same level of damage reduction associated with Alternative 3 in these reaches. However, storm damages from baseline stations 1135+00 to 1165+00 (Reaches 114 to 116) could be $5.40 million/year greater than the No Action Alternative if all of the present structures remain in place. As a result of the potentially greater storm damages, Alternative

4 would only reduce storm and erosion damages by $8.22 million/year for the entire project area.

Cumulative Effects. If all of the structures remained in place as assumed for Alternative 4, rental income and household spending would be maintained as with Alternative 3. More than likely, repeated storm damage to development in Reaches 114 to 116 could eventually result in the removal or demolition of all oceanfront structures in these areas. This would ultimately reduce rental income and household spending. On the other hand, the removal of structures from Reaches 114 to 116 would also decrease the potential for storm damages. Prediction of when or if structures would be removed from Reaches 114 to 116 under Alternative 4 were not made due to the uncertainty associated with individual decisions that would be associated with such actions.

In the absence of an inlet management plan, construction of the 14-foot (NAVD) dune plan in the areas where hardbottoms encroach close to shore would be problematic given the limited volume of coarse grain material available from the offshore borrow area. This could result in either the exclusion of some sections of the North Topsail Beach shoreline or greatly reduced beach fill design sections in the hardbottom areas. In this regard, the 2000 tax value of properties located within the near shore hardbottom areas, which extend from Reaches 84 to 90 and Reaches 1020 to 1160, total approximately $110 million.

Periodic nourishment of the beach fill project would have to be accomplished entirely from the offshore borrow area or with material from an upland source. Since construction of the project using the offshore borrow area will deplete the known source of coarse material, a new source of coarse offshore material will have to be identified in order to avoid possible impacts on the nearshore hardbottom resources.

If the cost associated with the use of upland borrow areas is reasonable, a possible upland source of material would have to be identified and geotechnical investigations conducted to characterize the quality of the upland material. These costs, however, were found to be quite high with a unit cost of $38.20/cy. The total initial cost using truck haul for the Central and North Sections and dredging the offshore borrow area for the South Section is estimated to be $156,452,000 (see Appendix B- Engineering Analysis).

Alternative 5: Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas

Direct and Indirect Impacts. The total volume of material that would be placed in the North and Central Sections during initial construction totals 2,703,500 cubic yards. Estimated erosion losses from these two sections totals 146,000 cubic yards/year. Assuming uniform loss of the fill material over time, all of the material would be eroded in 19 years. The protective value of Alternative 5 would initially

equal that of Alternative 3 but would gradually return to the pre-project or No Action (Alternative 1) condition by year 19. For the Central Section, damages would increase from $2.51 million/year immediately following construction to $5.74 million/year by year 19. Along the North Section, damages would increase from $5.76 million/year to $17.69 million/year in year 19. For the 6% discount rate used in the analysis for all alternatives, the equivalent average annual damages for the modified Alternative 5 (no periodic nourishment) would be $4.51 million/year while annual damages in the North Section would total $15.93 million/year.

Cumulative Effects. Cumulative impacts were not assessed under this alternative. At this time, additional offshore borrow areas containing sufficient volumes of coarse material to sustain the project for 30 years have not been identified.

Alternative 6: Inlet Management Plan

Direct and Indirect Impacts. Direct and indirect impacts were not assessed under this alternative.

Cumulative Effects. Alternative 6 would theoretically maintain the existing tax base for North Topsail Beach at the expense of increasing the storm damages to structures that were predicted to be moved or demolished under the No Action Alternative. Storm damages in the Central and North Sections would total $43.63 million/year with Alternative 6 or $20.20 million/year greater than the No Action Alternative.

Due to the high level of storm damage potential, relocation and/or demolition of buildings that would experience repeated storm damage is likely since most of the buildings in the Central and North Sections are not covered by flood insurance. The decision to relocate or demolish buildings subjected to repeated storm damage would be made by individual property owners based on their specific circumstances and therefore could not be factored into this analysis. In any event, negative impacts on the Town's tax base would be likely under Alternative 6.

5.16 NON-RELEVANT RESOURCE ISSUES

The following issues have been determined to be non-relevant due to the absence of project affects on the resource.

5.16.1 Noise. Construction based on the recommended alternatives would temporarily (less than three months) raise the noise level in the areas of the dredge and the discharge point on the beach and at the closure dike site. Construction equipment would be properly maintained to minimize these effects in compliance with local laws.

5.16.2 Energy Requirements and Energy Conservation.

Alternatives 1 and 2: No Action and Buy-Out/Relocation

The impacts of Alternatives 1 and 2 would be essentially the same as described below.

Direct and Indirect Impacts. No impacts are anticipated.

Cumulative Impacts. No impacts are anticipated.

Alternatives 3, 4, 5 and 6: Inlet Management Plan with Beach Nourishment, Beach Nourishment without the Relocation of New River Inlet Bar Channel, Beach Nourishment with One-Time Relocation of New River Inlet Bar Channel and Periodic Nourishment from Offshore Borrow Areas, and Inlet Management Plan

Direct and Indirect Impacts. Energy requirements for the proposed alternatives would be confined to fuel for the dredge, labor transportation, and other construction equipment.

Cumulative Effects. Cumulative impacts are not anticipated.

5.17 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

The following section delineates the applicable Federal and State regulations with which the Inlet Management Plan with Beach Nourishment alternative must comply prior to issuance of agency approvals for project implementation. Table 22 provides a summary of the applicable regulations and the compliance status of the project.

5.17.1 National and State Environmental Policy Acts. The proposed project will be in full compliance with the National Environmental Policy Act of 1969 and the State Environmental Policy Act of 1971.

5.17.2 Endangered Species Act of 1973. Coordination with the U.S. Fish and Wildlife Service and NOAA National Marine Fisheries Service (NMFS) includes consultation under Section 7 of the Endangered Species Act of 1973, as amended. The project will be coordinated fully under the Endangered Species Act (ESA). A biological assessment under ESA has been submitted to USFWS NOAA for species consultation under their perspective review.

5.17.3 Fish and Wildlife Coordination Act of 1958. Consultation with the U.S. Fish and Wildlife Service indicates that a Coordination Act Report may not be required for this project; however, direct coordination and consultation with the

Service will continue throughout the development of the project. This project will be in full compliance with this Act.

5.17.4 National Historic Preservation Act of 1966.

Cultural resource surveys were conducted within the offshore borrow area by the USACE in 2005 and by Tidewater Atlantic (TAR) in 2007. The results of these surveys determined that no submerged cultural resources were identified in this location, therefore no submerged cultural resources will be impacted by excavation of the proposed borrow area (Appendix E). These results were provided to SHPO and their offices concurred that no cultural resources will be affected. Compliance to the SHPO will continue through the initial construction phases and each maintenance event.

5.17.5 Clean Water Act of 1972. An application for Section 401 Water Quality Certification will be submitted to the North Carolina Division of Water Quality. All State water quality standards will be met under this project.

A Section 404 evaluation under the Clean Water Act has been applied for concurrently with the release of this Final Environmental Assessment. The project is expected to be in full compliance with this Act.

5.17.6 Clean Air Act of 1972. No air quality permits will be required for this project. Exhaust emissions from labor transport and dredge equipment would likely be well under the *de minimus* levels for ozone non-attainment areas (40 CFR 91.853).

In response to a U.S. Environmental Protection Agency (EPA) requirement, the State of North Carolina recommended that 11 counties and parts of 24 others be designated by the Federal government as not meeting air pollution control standards for ozone. Onslow County was listed as non-attainment areas in the State of North Carolina. A final decision based on the recommendations provided by North Carolina will be made by the EPA to determine which areas are listed as non-attainment areas.

Non-attainment areas are the focus of air quality plans for controlling ozone in the State of North Carolina. These plans would include specific proposals for curbing ozone, such as measures to reduce emissions from cars, trucks, industries, and power plants.

This project is being coordinated with the EPA and will be in compliance with Section 309 of the Act. The Environmental Impact Statement developed for this project will be forwarded to the EPA for their comments.

5.17.7 Coastal Zone Management Act of 1972. A federal consistency determination in accordance with 15 CFR 930 Subpart C will be included in this

report. State consistency review will be performed during the coordination of the Final EIS document to ensure that the project is consistent with the North Carolina Coastal Area Management Act (CAMA) of 1974, as amended 1981 (Ch. 932, s. 2.1). The permit application has been submitted to CAMA and is currently under review.

5.17.7.1 North Carolina Technical Standards for Sediment Criteria of 2007. Based on the current North Carolina Technical Standards for Beach Fill Projects (15A NCAC 07H .0312), detailed analyses were performed to determine the percentages of silt, granular, and gravel sized clasts, as well as the percentage of carbonate by weight and amount of clasts greater than three inches in the native beach material. The State standards require percent silt, granular, and gravel in fill material not to exceed the amount found in the native beach plus five (5) percent. Likewise, the State standards require the percent carbonate in beach fill not to exceed the amount found in the native beach plus fifteen (15) percent.

Table 22
Regulatory Compliance

Regulation	Lead Agency	Compliance Determination
National Environmental Policy Act of 1969	U.S. Environmental Protection Agency	Status Pending
State Environmental Policy Act of 1971	NC Department of Environmental and Natural Resources	Status Pending
Endangered Species Act of 1973	U.S. Fish and Wildlife Service & National Marine Fisheries Service, NC Department of Environmental and Natural Resources	Status Pending
Fish and Wildlife Coordination Act of 1958	U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers	Status Pending
National Historic Preservation Act of 1966	NC State Historic Preservation Office	Final
Clean Water Act of 1972 Section 404 Section 401	U.S. Environmental Protection Agency U.S. Army Corps of Engineers NC Division of Water Quality	Status Pending
Clean Air Act of 1972	U.S. Environmental Protection Agency NC Department of Environmental and Natural Resources	Status Pending
Coastal Zone Management Act of 1972	National Oceanic and Atmospheric Administration Ocean and Coastal Resource Management	Status Pending
North Carolina Technical Standards for Sediment Criteria	NC Department of Coastal Management	Status Pending
Marine Mammal Protection Act	U.S. Fish and Wildlife Service	Status Pending
Federal Water Project Recreation Act as amended in 1976	U.S. Fish and Wildlife Service	Status Pending
Fishery Conservation and Management Act of 1976	National Marine Fisheries Service	Status Pending
Submerged Lands Act of 1953	National Oceanic and Atmospheric Administration NC Department of Coastal Management	Status Pending
Coastal Barrier Resources Act and Coastal Barrier Improvement Act of 1990	U.S. Fish and Wildlife Service	Status Pending
Section 10 Rivers and Harbors Act of 1899	U.S. Army Corps of Engineers	Status Pending

Anadromous Fish Conservation Act as amended in 1965	National Marine Fisheries Service U.S. Fish and Wildlife Service	Status Pending
Migratory Bird Treaty Act as amended 1998 and Migratory Conservation Act as amended 1989	U.S. Fish and Wildlife Service	Status Pending
Magnuson-Stevens Fishery Conservation and Management Act of 1996	National Marine Fisheries Service	Status Pending

5.17.8 Marine Mammal Protection Act of 1972. Incorporation of the safe guards used to protect threatened and endangered species during dredging and disposal activities would also protect any marine mammals in the area, therefore, this project is in compliance with the Act. A trained and government certified sea turtle and marine mammal observer may be stationed on the dredge during all water-related construction activities. Appropriate actions will be taken to avoid listed sea turtle and marine mammal species effects during project construction. If a marine mammal is identified within the project boundaries, they will be provided protections equal to the ESA species that have had consultations completed, and as a result of this the project sponsor is in compliance with the Act.

5.17.9 Federal Water Project Recreation Act as amended in 1976. The principles of this Act (Public Law 89-72), as amended, will be fulfilled by complying with cost sharing responsibilities as outlined in Section 3.

5.17.10 Fishery Conservation and Management Act of 1976. Coordination with the National Marine Fisheries Service (NMFS) will continue during the review of the Draft EIS. The project will be in full compliance with this Act.

5.17.11 Submerged Lands Act of 1953. The project will occur on submerged lands of the State of North Carolina. The project will continue to coordinate with the State to ensure full compliance with this Act.

5.17.12 Coastal Barrier Resources Act and Coastal Barrier Improvement Act of 1990. Portions of North Topsail Beach are listed as undeveloped coastal barrier as defined by the Coastal Barrier Resources Act.

5.17.13 Section 10 Rivers and Harbors Act of 1899. The proposed activities will involve a temporary restriction of navigable waters of the United States during construction. This temporary restriction will last for no more than 30 days. The proposed action is subject to the public notice, public hearing, and other evaluations normally conducted for activities subject to the act. The project will be in full compliance with this Act.

5.17.14 Anadromous Fish Conservation Act as amended in 1965. The project will be coordinated with the National Marine Fisheries Service and will be in compliance with the Act.

5.17.15 Migratory Bird Treaty Act as amended 1998 and Migratory Conservation Act as amended 1989. Monitoring efforts of the project include identifying the bird species that utilize the Permit Area prior to and post-construction activities. The project is not expected to affect the migratory birds that utilize the area; however a full assessment will be conducted as part of the project efforts. The project will be in full compliance with this Act.

5.17.16 Magnuson-Stevens Fishery Conservation and Management Act of 1996. The project will be coordinated with the National Marine Fisheries Service and will be in compliance with the Act. The Essential Fish Habitat Assessment has been submitted to the National Marine Fisheries for their review. Efforts to comply with the Act are ongoing.

Table 23 provides a summary of the impacts and changes to the associated resource as a result of the implementation of each alternative.

Summary of Direct, Indirect, and Cumulative Impacts
North Topsail Beach, North Carolina

Environmental Factors North Topsail Beach, North Carolina	**Alternative 1 No Action**	**Alternative 2 Buy Out/Relocation**	**Alternative 3 Inlet Management Plan with Beach Nourishment**	**Alternative 4 Beach Nourishment without Channel Relocation**	**Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)**	**Alternative 6 Inlet Management Plan**
5.3 PERMIT AREA HABITATS						
5.3.1 Estuarine	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
5.3.1.1. Salt Marsh Communities	No direct impact. Indirect impacts include potential changes in the tidal flow patterns adjacent to and within the salt marshes. Cumulative impacts include transitions between high marsh and low marsh causing a shift in faunal community composition.	Same as Alternative 1.	Minimal direct impact including temporary displacement of foraging species and temporary increases in turbidity during construction and future maintenance events. Cumulative impacts include a deficit of inorganic sediment accumulation in the back barrier low marsh habitat.	Positive direct impact includes protecting low marsh habitat. Minimal direct impact including temporary displacement of foraging species and temporary increases in turbidity during construction and future maintenance events. Cumulative impacts include transitions between high marsh and low marsh causing a shift in faunal community composition. Cumulative impacts include a deficit of inorganic sediment accumulation in the back barrier low marsh habitat.	Minimal direct impact including temporary displacement of foraging species and temporary increases in turbidity during construction and future maintenance events. Minor cumulative impact includes vulnerability to overwash.	Minimal direct impact including temporary displacement of foraging species and temporary increases in turbidity during construction and future maintenance events. Minimal positive cumulative effects include increased storm protection.

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
High Salt Marsh	No direct impact. Indirect impacts include potential changes in the tidal flow patterns adjacent to and within the salt marshes. Cumulative negative effects include the transition of high marsh into low marsh. Cumulative positive impacts will occur at other locations where low marsh will transition to high marsh causing a shift in faunal community composition.	Same as Alternative 1.	Minimal direct impact including temporary displacement of foraging species and temporary increases in turbidity during construction and future maintenance events.	Minimal direct impact including temporary displacement of foraging species and temporary increases in turbidity during construction and future maintenance events. Positive indirect cumulative impact includes transition from low marsh into high marsh causing a shift in faunal community composition.	Minor cumulative impact includes vulnerability to overwash.	Minimal direct impact including temporary displacement of foraging species and temporary increases in turbidity during construction and future maintenance events. Minimal positive cumulative impacts include increased storm protection.

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
Low Salt Marsh	No direct impact. Indirect impacts include potential changes in the tidal flow patterns adjacent to and within the salt marshes. Cumulative positive impacts include the transition of high marsh into low marsh. Cumulative negative impacts will occur at other locations where low marsh will transition to high marsh causing a shift in faunal community composition..	Same as Alternative 1.	Cumulative impact includes a deficit of inorganic sediment accumulation in the back barrier low marsh. There is potential for temporary increases in turbidity associated with the proposed project and future maintenance events.	Positive cumulative impacts include protection for the low marsh. Negative indirect cumulative impact includes transition from low marsh into high marsh causing a shift in faunal community composition.	Minor cumulative impact includes vulnerability to overwash.	Minimal direct impact including temporary displacement of foraging species and temporary increases in turbidity during construction and future maintenance events. Minimal positive cumulative impacts include increased storm protection.

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
5.3.1.2 Submerged Aquatic Vegetation (SAV)	Cannot be determined due to no known habitat within the Permit Area.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
5.3.1.3 Shellfish	No direct, indirect, or cumulative impacts are expected due to the far proximity of this habitat from the inlet and beach environment.	Same as Alternative 1.	No direct, indirect, or cumulative impacts are expected due to the far proximity of this habitat from the inlet and beach environment.	No direct, indirect, or cumulative impacts are expected due to the far proximity of this habitat from the inlet and beach environment.	No direct, indirect, or cumulative impacts are expected due to the far proximity of this habitat from the inlet and beach environment.	No direct, indirect, or cumulative impacts are expected due to the far proximity of this habitat from the inlet and beach environment.

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
5.3.2.1 Upland Hammock	Direct and indirect impact includes vulnerability to saltwater intrusion. Cumulative impacts include increased saltwater intrusion and a transition to estuarine habitats.	Same as Alternative 1.	No direct or indirect impact. Positive cumulative impact along Onslow Beach through the creation of additional habitat for upland hammock vegetative species.	Direct and indirect impact includes vulnerability to saltwater intrusion. Cumulative impacts include increased saltwater intrusion and a transition to estuarine habitats.	Positive direct impact created by protection due to nourishment. No indirect impact because without maintenance the protection will not persist. Cumulative impacts will include the transition of dry upland areas to estuarine habitat.	No direct or indirect impact. Positive cumulative impact includes the increase of upland hammock habitat vegetation.

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
5.3.2.2 Inlet Dunes and Beaches	Direct impact includes the continuation of natural shoreline erosion with the potential for loss of dune resources. Cumulative impact includes the total loss of the dune complex and the species they support.	Same as Alternative 1.	Direct and indirect impacts include the reduction of natural erosion rates. Positive direct and indirect impacts include the widening of the sandy beach to which creates suitable habitat for dune vegetation and will provide shoreline protection. Positive cumulative effects include accretion and recovery for the shoreline and dunes.	No direct or indirect impacts due to nourishment. Without the relocation of the inlet, the beaches and dunes will remain subject to natural erosion. The continuation of these natural erosion rates will translate to negative cumulative impacts.	Positive short term indirect effects include stabilization of the shoreline and reduction of erosion. Negative cumulative impacts include the continuation of erosion on the shorelines leading to a reduction in inlet dune and beach habitat.	Positive direct and indirect impacts include the reduction of erosion and the stabilization of shoreline. Positive cumulative impacts include reduction of loss of habitat due to erosion.

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
5.3.2.3 Intertidal Flats and Shoals	No direct or indirect impacts. Cumulative impacts include the increase of sediment on flats and shoals with potential of elimination through the conversion to supratidal habitats.	Same as Alternative 1.	Direct and indirect impacts include increased turbidity and a reduction of habitat area via the removal of portions of the ebb tide delta. Direct impacts also include the removal of benthic infauna and functionality of the habitat due to dredging.	No direct or indirect impacts. Cumulative impacts include reduction of habitat due to increases sediment transportation.	Direct and indirect impacts include increased turbidity and a reduction of habitat area via the removal of portions of the ebb tide delta. Direct impact includes reduction in habitat area and the removal of benthic infauna and functionality of the habitat due to dredging. Short term negative cumulative impacts include mortality of those infaunal species not adapted to avoidance of burial at the fill site and entrainment from the borrow area.	Direct and indirect impacts include increased turbidity and a reduction of habitat area via the removal of portions of the ebb tide delta. Direct impacts also include the removal of benthic infauna and functionality of the habitat due to dredging. Recovery would be impacted due to ongoing maintenance. Cumulative impacts include the removal of benthic infauna and functionality of the habitat due to dredging.

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
5.3.3 BEACH AND DUNE HABITATS						
5.3.3.1 DUNE COMMUNITIES	Long term direct and indirect and cumulative impacts include a continuation of natural shoreline erosion with a continued loss of dune resources and threatening the dune vegetation, as well as degrading the habitat used by several species of roosting, foraging and nesting shorebirds and plant species such as seabeach amaranth .	Same as Alternative 1.	Positive direct and indirect impacts include the rebuilding of the dunes in the north and central sections of the shoreline to a height of 14 feet along with the slowing of the recession rate at Onslow Beach. Positive cumulative impacts include shoreline recovery along a majority of North Topsail	The direct impact will be positive due to the greater beach width and the restored 14 foot (NAVD) dune heights. Indirect impacts will be negative because without realignment of the New River Inlet the beaches and dunes are expected to continue to erode. This will affect the vegetation that provides habitat to several species of	Positive direct impacts include protection against beach and dune erosion. Negative indirect and cumulative impacts include erosion along the oceanfront shoreline and a further reduction in dune habitat.	Direct and indirect impacts will be negative due to the continuation of the dune system to erosion caused by storm damage. Negative cumulative impacts would also include reduction of dune vegetation and birds that use dune habitats for roosting, foraging and nesting.

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			Beach. Based on shoreline change analysis, Onslow Beach dune communities will be negatively impacted by the periodic maintenance of New River Inlet and nourishment of North Topsail Beach.	roosting, foraging and nesting shorebirds. cumulative effects include continued erosion on North Topsail and Onslow Beaches.		

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
5.3.3.2 DRY BEACH COMMUNITIES	Negative indirect, direct, and cumulative impacts include the continued erosion of the North Topsail Beach and Onslow Beach shorelines, resulting in net loss of dry beach habitat and the communities they support including turtles and seabirds.	Same as Alternative 1	Positive direct and indirect impacts include the restoration of North Topsail Beach's shoreline. Inlet realignment would initiate accretion along the northeast beaches. Erosion will slow at Onslow Beach, and the reconfigured ebb tide delta should add material to the southwest end of Onslow Beach, potentially increasing the amount of dry beach. The increase of dry beach will also positively affect shorebirds, water birds and colonial birds that utilize this habitat.	The immediate direct impact of this alternative on dry beach habitat would be positive, due to the greater beach width. Negative indirect impacts include storm damage and greater exposure to wave energy. Negative cumulative impacts include the continuation of erosion and recession of dry beach affecting affect sea turtle and the habitat utilized by several species of roosting, foraging and nesting shorebirds.	Same as Alternative 4	Positive direct impacts include shoreline stabilization to a portion of the north and central sections. Negative indirect and cumulative impacts from storm damage will lead to erosion and reduction of the dry beach habitat affecting sea turtles and birds.

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5.3.3.3. WET BEACH COMMUNITIES	Negative Direct and indirect impacts include continued shoreline erosion reducing the width of the wet beach area negatively affecting many benthic organisms, birds, and finfish. No cumulative impacts are expected.	Same as Alternative 1	Negative direct impacts include burial of the wet beach due to the addition of beach fill to North Topsail Beach. This would negatively impact the birds and fish that forage on the organisms that reside in the buried wet beach. No cumulative impacts.	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3
5.3.4 MARINE HABITATS						
5.3.4.1 NEARSHORE SOFTBOTTOM COMMUNITIES	No direct or indirect impacts. Negative cumulative impacts include alteration of	Same as Alternative 1	Periodic nourishment would directly, indirectly, and	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
	the composition of micro and macrofauna present within the system which affect lower trophic organisms by reducing primary production and/or affect higher trophic organisms by reducing select food availability		cumulatively affect softbottom communities and the nearshore softbottom community food chain through the continuation of sand placement on the habitat.			
5.3.4.2 OFFSHORE SOFTBOTTOM COMMUNITIES	Direct and indirect impacts would be negligible while density and abundance may fluctuate over time but would remain persistent and consistent overall. Cumulative impacts may negatively affect	Same as Alternative 1	Direct and Indirect impacts include mortality of all organisms present within the dredged material. The offshore softbottom community food chain may be affected by long-	Same as Alternative 3	Same as Alternative 3	Same as Alternative 3

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	food chains through the natural seasonal variations or storm events.		term cumulative affects from dredging operations, natural seasonal variations and storm events.			
5.3.4.2 HARDBOTTOM COMMUNITIES						
5.3.4.2.1 NEARSHORE HARDBOTTOM	Direct, indirect, and cumulative impacts include natural short-term and long-term covering of hardbottom recourses.	Same as Alternative 1.	Direct impacts include potential for increased sediment deposition on this resource. Cumulative impacts include natural long-shore transport of sediments which may indirectly affect nearshore	Direct and indirect impacts include covering of hardbottom as avoidance of the resources would not be possible. Cumulative impacts would be avoided if alternative borrow areas are identified.	No Direct, indirect, or cumulative impacts are expected. Cumulative community species	Same as Alternative 3.

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			hardbottom by temporarily covering hardbottom resources due to existing natural conditions and/or seasonal variations.			
5.3.4.2.2 Offshore Hardbottom	Other than impacts through natural processes, no direct, indirect, or cumulative impacts are expected.	Same as Alternative 1.	Direct, indirect, and cumulative impacts are not expected.	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 1.
5.4.1 Water Quality						
5.4.1 Turbidity	Direct and indirect impacts would be minimal with some increased changes to turbidity during storms. No cumulative impacts are expected.	Same as Alternative 1.	Direct and indirect impacts would be minimal. No cumulative impacts are expected.	Same as Alternative 1.	Same as Alternative 3.	Same as Alternative 3.

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5.4.2 Salinity	No Impacts expected.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
5.5 Air Quality	No Impacts expected.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
5.6 Public Safety	Direct, indirect, and cumulative impacts include the destruction of homes on the north end of North Topsail Beach which could expose workers to risk of injury. Debris could fall into the nearshore which could pose health threats to people swimming. Continued erosion would undermine existing roads, and sanitary systems, expose electrical	Same as Alternative 1.	No impacts expected.	No impacts expected.	No impacts expected.	No impacts expected.

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	lines, and rupture water supply system, exposing the public to increased risk of injury and/or infection.					
5.7 Aesthetic Resources	Direct and indirect impacts would include the abandonment and/or demolition of homes and other structures. Cumulative impacts would include significant loss of land, personal property, and roads, which would negatively affect the aesthetic quality of North Topsail Beach.	Same as Alternative 1.	Positive direct, indirect, and cumulative impacts would include the restoration of the aesthetic qualities of a stable oceanfront shoreline.	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 3.

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
5.8 Recreational Resources	Negative direct, indirect, and cumulative impacts include the continued loss of the beach access.	Same as Alternative 1.	Positive direct, indirect, and cumulative impacts include the creation of a wider recreational beach and increased access to the inlet.	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 3.
5.9 Navigation	No direct or indirect impacts are expected. Negative cumulative impacts include reduced access through the inlet for commercial fishing vessels as the depth decreases.	Same as Alternative 1.	Positive direct, indirect, and cumulative impacts would include the formation of a relatively deep channel for some period of time following its construction.	Same as Alternative 1.	Positive direct and indirect impacts would create the formation of a relatively deep channel for a short period of time following its construction. No cumulative impacts are expected.	Same as Alternative 3.
5.10 Infrastructure	Negative direct and indirect impacts include the	Same as Alternative 1.	No impacts expected.	No impacts expected.	No impacts expected.	No impacts expected.

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
	continued erosion of the oceanfront shoreline which could result in the destruction of homes, roads, and service utilities. If threatened structures are not moved, they would have to be demolished with the debris deposited in local sanitary landfills. Cumulative impacts could reduce the amount of space available at the local landfill over the next ten years.					
5.11 Urban Quality	Direct and indirect impacts would include the	Same as Alternative 1.	Positive direct, indirect, and cumulative	Same as Alternative 3.	Same as Alternative 3.	Same as Alternative 3.

Environmental Factors North Topsail Beach, North Carolina	Alternative 1 No Action	Alternative 2 Buy Out/Relocation	Alternative 3 Inlet Management Plan with Beach Nourishment	Alternative 4 Beach Nourishment without Channel Relocation	Alternative 5 Beach Nourishment with One-Time Channel Relocation (No Maintenance)	Alternative 6 Inlet Management Plan
	abandonment and/or demolition of homes and other structures. Cumulative impacts would include significant loss of land, personal property, and roads, which would negatively affect the urban quality of North Topsail Beach.		impacts on urban quality would include the restoration of the oceanfront shoreline.			
5.12 Solid Waste	Negative direct and indirect impacts include the continuation of erosion on the oceanfront shoreline resulting in the destruction of homes, roads, and service utilities. If threatened	Same as Alternative 1.	No impacts expected.	No impacts expected.	No impacts expected.	No impacts expected.

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	structures are not moved, they would have to be demolished with the debris deposited in local sanitary landfills.					
5.13 Drinking Water	Direct and indirect impacts include excessive erosion which could affect the potable water distribution system that serves the north end of North Topsail Beach. The Town would have to disconnect impacted sections of the water line and reroute it to serve remaining properties. This would cause a boil	Same as Alternative 1.	No impacts are expected.	No impacts are expected.	No impacts are expected.	No impacts are expected.

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	water directive for all affected residents. These negative impacts on drinking water would be continuous and cumulative as long as the inlet shoreline continues to migrate to the east.					
5.14 Economics	Direct and indirect impacts are not considered. Cumulative impacts include significant economic loss to the Town, County, and State averaging $33.3 million/year for the Central and North Sections. Reduction of tax revenue would also	Same as Alternative 1, except temporary sand bag revetments would not be used to protect threatened structures.	Positive direct and indirect impacts include protection of the tax base in the Central and North Sections of North Topsail Beach against losses due to a continuation of long-term erosion. Cumulative impacts include	Positive direct and indirect impacts include a reduction of storm and erosion damages by $8.22 million/year for the entire project area. Positive cumulative impacts are unknown.	Direct, indirect, and cumulative impacts were not assessed.	Direct and indirect impacts were not assessed. Cumulative impacts would include a reduction of the city's tax base due to continued storm damage.

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	include $366,100/year reduction in ad valorem tax revenues for the Town and County. Room accommodation tax revenues would be reduced by an average of $254,600/year while sales tax revenues would be reduced by $395,200/year. An 8,000-foot section of New River Inlet Road would need to be relocated,		costs for using upland borrow sources to construct and/or maintain Alternative 3.			